AMPHIBIAN & REPTILE CONSERVATION

IRAN

Cover: The Iranian spider-tailed horned viper (*Pseudocerastes urarachnoides*), an outstanding viper, ambushing for prey in its natural habitat, in Ilam province, western Iran. The viper coloration is confused with its background and hard to see. While ambushing for prey the bird prey (species of *Lanius*) is observing the snake's tail, near the head, and the tail propels like a tarantula on the move. The bird is attracted to the "tarantula" and is suddenly caught by the viper and held until its venom kills. The case, a very specialized behavior for attracting prey, is a kind of fatal mimicry. Many biological and ecological aspects of the viper including conservation status, exact distribution, reproductive strategy, annual cycles, molecular systematics, and population genetics are unknown but being investigated by Behzad Fathinia, Razi University, Kermanshah, Iran. *Photograph: Behzad Fathinia.*

Instructions to Authors: *Amphibian & Reptile Conservation* accepts manuscripts on the biology of amphibians and reptiles, with emphasis on conservation, sustainable management, and biodiversity. Topics in these areas can include: taxonomy and phylogeny, species inventories, distribution, conservation, species profiles, ecology, natural history, sustainable management, conservation breeding, citizen science, social networking, and any other topic that lends to the conservation of amphibians and reptiles worldwide. Prior consultation with editors is suggested and important if you have any questions and/or concerns about submissions. Further details on the submission of a manuscript can best be obtained by consulting a current published paper from the journal and/or by accessing Instructions for Authors at the *Amphibian and Reptile Conservation* website: http://amphibian-reptile-conservation.org/submissions.html

Editorial

Amphibian & Reptile Conservation *continues to publish relevant topical issues for herpetological conservation including those on the countries of Iran (this issue), Sri Lanka (following issue), and general interest papers on the biodiversity and sustainability of amphibian and reptilian species worldwide. Other issues currently publishing papers are on the topics of: Conservation Breeding Programs, Giant Salamanders, and our first Global issue (No. 1) for papers (all issues dated 2012-2013) that do not fit a topical issue.* Amphibian & Reptile Conservation *will continue to release new papers as they are completed through 2013 on these subjects.*

Amphibian & Reptile Conservation *is experiencing tremendous growth and this is due to the hard work and recent additions of many new editors and advisors. Among these important additions are Howard Clark as our new graphic designer who has shown unmatched commitment and expertise in developing* Amphibian & Reptile Conservation *into a major herpetological publication.*

The future is bright for Amphibian & Reptile Conservation *that specializes in producing papers of relevance and impact toward perpetuating herpetological biodiversity.* Amphibian & Reptile Conservation *will continue to publish the best in papers that present information distinguished by numerous full-color photographs, excellent graphic design, and a superior distributional network. We aim for the widest global readership through open access publishing and supported by our large social networks.*

As the readership of Amphibian & Reptile Conservation *increases, we extend an open invitation for those who see our vision of producing and publishing* Amphibian & Reptile Conservation *as a major contributor to herpetological conservation and our ever expanding global audience to support this vision.*

Craig Hassapakis, Editor, Publisher, and Founder
Howard O. Clark, Jr., Associate Editor

Guest Editorial: Iran Issue

When most people think of Iran, they envision a hot, dry land. Although much of the central area of the country fits this concept, Iran has a great geographical diversity and a corresponding floral and faunal diversity as well. Owing to the many geographically and ecologically distinct regions, a high percentage of the small animal species, including amphibians and reptiles, are limited, or endemic, to these areas. Because there is a long tectonic history of southwestern Asia, a result of collisions of Eurasia with the African and Indian plates and the near closing of the Tethys Sea, the region is a crossroads of distributions of the faunas, especially at the generic level, of animals originating in these three geographic realms. These genera have diverged during the periods of mountain and high plateau uplift and subsequent erosion to plains of great soil diversity, from course pebbles to aeolian deposits of sand and loess. Changes in elevation and changes in climate have created both barriers to and reconnections of faunal distributions. This paleogeographic dynamism has resulted in the greatest faunal diversity within the western Palearctic Realm.

Although the first accounts attempting to describe and catalog the Iranian fauna according to modern biosystematic principles took place during the mid-to-late nineteenth century, the number of species described, as well as interpretations of their evolutionary relationships has grown steadily. With the spread of greater scientific education in Iran and consequently, the growing number of zoologists, the twenty-first century has already seen a flowering of renewed interest in herpetological studies among those in a position to carry out long-term studies in ecology, and to initiate scientific approaches to conservation and wildlife management.

Some additional cultural and economic changes have strongly influenced the development of interest in wildlife and conservation in Iran. The growth of an educated middle class, along with access to modern field vehicles, cameras, climbing gear, GPS, etc., has created a generation of outdoor sportspersons with an appreciation and respect for nature. For example, there are now excellent photographs available of most categories of animals.

The papers in the current issue reflect something of the variety of herpetological projects being carried out currently by Iranian herpetological specialists. Few of the papers here can be characterized as conventional "conservation studies" investigating the broader issues of herpetological conservation. However, to be meaningful conservation studies require descriptive data of species and habitats, species distribution, and syntopy, and these are the kinds of studies represented in this issue (Iran) of *Amphibian & Reptile Conservation*.

As in most countries, conservation efforts for amphibians and reptiles are incidental to conservation of larger species of wildlife, for which protected areas are designated. Throughout the history of western cultures, reptiles and amphibians have been reviled and persecuted. In Iran, the Zoroastrians were persistent destroyers of these animals, which were regarded as associated with the dark and evil force of nature. Neither Islam nor Christianity held them in much higher regard. Only lately have they been seen as integral units in ecological systems.

Steven C. Anderson, Guest Editor

Distribution of *Hemidactylus* geckos (Reptilia: Gekkonidae) in Fars Province, Southern Iran

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Abstract.—During extensive field work on the reptiles of Fars Province, Iran from November 2007 to September 2010, a total of 18 specimens of *Hemidactylus*, belonging to three species, were collected. In April 2010 a single specimen of *H. turcicus*, with two additional specimens in September 2010, were collected from different urban areas close to a mountainous region in the city of Varavi, 25 km from the city of Lamerd, in southwestern region of Fars Province.

Key words. Lizard, *Hemidactylus*, distribution, Fars Province, southern Iranian Plateau

Introduction

The genus *Hemidactylus* Oken, 1817 comprises about 100 described species and is one of the most speciose genera of the second most species-rich lizard family in the world, Gekkonidae, as well as one of the most widely distributed genera of geckos (Carranza and Arnold 2006; McMahan and Zug 2007; Sindaco et al. 2009; Javed et al. 2010). These geckos are distributed over large parts of Africa, Mediterranean Europe, southern Asia, Oceania, and tropical America, with the main center of speciation in Somalia and its adjoining areas (Carranza and Arnold 2006; Sindaco et al. 2007, 2009; Giri and Bauer 2008). Somalia, Kenya, Ethiopia, and Eritrea host more than 40 species of *Hemidactylus*, most of which are endemics (Sindaco et al. 2007, 2009; Spawls and Largen 2010). However, the great majority of *Hemidactylus* species have relatively small distributions confined to southern Asia and Africa, with only eight species namely *H. brookii, H. bowringii, H. flaviviridis, H. frenatus, H. garnotii, H. persicus, H. mabouia,* and *H. turcicus* colonizing most of the geographical extent of this genus (Carranza and Arnold 2006; Giri and Bauer 2008; Javed et al 2010). The gekkotan fauna of Iran includes about 45 species (Anderson 1999; Rastegar-Pouyani et al., 2008). Among these, Iran hosts four species of *Hemidactylus* geckos including: *H. persicus* J. Anderson, 1872; *H. turcicus* (Linnaeus 1758); *H. flaviviridis* Rüppell, 1840; and *H. robustus* Heyden, 1827 (Rastegar-Pouyani et al. 2008). Fars Province (Fig. 1) has one of the most diverse climates in southern Iran and is of great significance in

terms of amphibian and reptilian fauna owing to geographical and zoogeographical features. After carrying out field work in various regions of Fars Province, we aim here to update the knowledge of the genus *Hemidactylus* in this region and report our findings.

Materials and methods

The province of Fars covers a land area of about 125,000 km² (7.6% of total area of Iran) and is located between latitudes 27°-31°N and longitudes 50°-55°E. The region is bordered to the north by Esfahan and by Kohgiluyeh and Boyer Ahmad Provinces, to the south by Hormozgan Province, to the west by Bushehr Province, and to the east by Yazd and Kerman Provinces. The elevational range in this province extends from 4050 m in the northern parts (Boll Mountain) to about 450 m in the southern parts, with a mean of 1491 m. The mean yearly precipitation ranges from 150 mm to 1200 mm. This survey was carried out from November 2007 to September 2010. The material collected during this survey consists of 18 specimens of *Hemidactylus* which are now deposited in the Collection of the Biology Department of Shiraz University (CBSU), Iran (see material examined). The collected specimens were kept at low temperature (0°C), fixed in 75% ethanol, and then identified using valid identification keys (Leviton et al. 1992; Anderson 1999; Rastegar-Pouyani et al. 2006). In April 2010, during our field work on the herpetofauna of southern regions of Fars Province, a single specimen of *Hemidactylus turcicus* (Fig. 2) was

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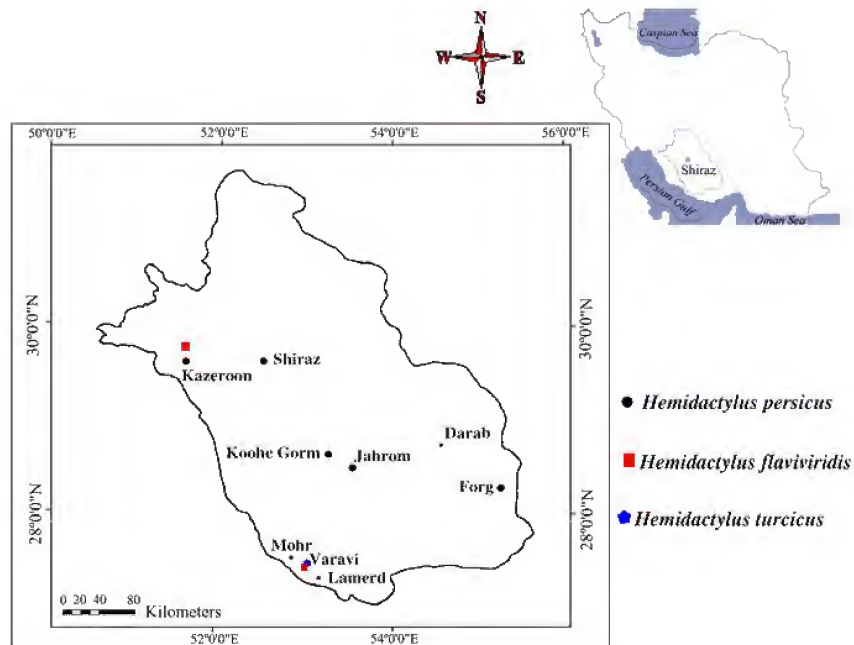
Figure 1. Location of Fars Province on the Iranian Plateau. The black circle, red quadrangular and blue polygon indicate the previous and new locality records for *H. persicus*, *H. flaviviridis*, and *H. turcicus*, respectively.

Figure 2. One of the three collected specimens of *Hemidactylus turcicus* from southwestern regions of Fars Province.

Figure 3. A specimen of *H. persicus* with autotomized tail from Shiraz, the capital of Fars Province.

Figure 4. A new specimen of *H. flaviviridis* from southwest of Fars Province.

Table 1. List of the previous (*) and new locality records of *Hemidactylus* in Fars Province.

Species	Locality	Coordinates
Hemidactylus persicus	Fork, Darab Township	28°17'04.1" N, 55°13'24.1" E; ele. 897 m
Hemidactylus persicus	Jahrom, Jahrom Township	28°57' N, 53°57' E, ele. 1050 m
Hemidactylus persicus	Shiraz, Shiraz Township	29°37' N, 52°32' E, ele. 1500 m
Hemidactylus persicus	Kazeroon, Kazeroon Township	29°37'6" N, 51°39'30" E, ele. 860 m
*Hemidactylus persicus**	Koohe Gorm Non Hunting Area, Jahrom Township	Zareian et al. 2010
*Hemidactylus flaviviridis**	Ghaleh Seied, approximately 25 km northwest of the Parishan Lake, Kazeroon Township	29°36'15" N, 51°32'51" E; ele. 900 m
Hemidactylus flaviviridis	Varavi, Mohr Township	27°27'58.36" N, 53°03'45.03" E; ele. 447 m
Hemidactylus turcicus	Varavi, Mohr Township	27° 28'21.12" N, 53° 03'00.20"E; ele. 421 m
Hemidactylus turcicus	Varavi, Mohr Township	27° 28'02.38" N, 53° 02'55.52"E; ele. 421 m

collected from the city of Varavi, 25 km from the city of Lamerd, and 15 km from the city of Mohr. The collected specimen was found active at night on the wall of a house near to a mountainous area. In September 2010, two additional specimens of *H. turcicus* were collected at midday in a house depot, approximately one km from the previous record. These two specimens were relatively active during midday, though they were fully active at night.

Results and discussion

Previous and new records of *Hemidactylus* in Fars Province are given in (Table 1). The newly collected specimens were identified as *H. turcicus* (Fig. 2), *H. persicus* (Fig. 3), and *H. flaviviridis* (Fig. 4). Among the collected material three specimens of *H. turcicus* are reported for the first time from Fars Province. So far, 14 species of gekkotan lizards have been reported from Fars Province. Of these, three species belonging to the genus *Hemidactylus* (Rastegar-Pouyani et al. 2006, 2008; Gholamifard et al. 2009, 2010) which are as follows:

Hemidactylus persicus Anderson, 1872. Persian gecko

The type locality of *H. persicus* is Iran but no exact locality was given. According to Smith (1935) the type speci-

men is from Shiraz in Fars Province (Anderson 1999). This species is distributed in Coastal eastern Arabia north to southern Iran and Iraq, east to Sind and Wazirestan, Pakistan. In Iran it is known from Ilam, Khuzestan, Chaharmahal and Bakhtiari, Kohgiluyeh and Boyer Ahmad, Fars, Bushehr, Hormozgan, Kerman, and Sistan and Baluchistan Provinces (Leviton et al. 1992; Anderson 1999; Rastegar-Pouyani et al. 2006, 2007). *Hemidactylus persicus* has been collected from five different localities in Fars Province (Table 1). The northernmost records are from Shiraz and the southernmost records from Forg (Darab Township), close to Hormozgan Province. According to our data, it seems that of the three species, *H. persicus* has the largest distribution range of any *Hemidactylus* species in Fars Province.

Hemidactylus flaviviridis Rüppell 1840. Yellow-bellied house gecko

The type specimen of *H. flaviviridis* is from Massawa Island, Eritrea (Anderson 1999). The yellow-bellied house gecko, has been reported occurring from the northeastern African and Arabian shores of the Red Sea and around the coast of Arabia and Iran, across Pakistan, eastern Afghanistan and northern India to West Bengal and south to the vicinity of Bombay (Anderson 1999). In Iran, *H. flaviviridis* has already been reported from the coastal towns and villages of southern Baluchistan, Kerman, Fars, and Khuzestan Provinces (Anderson 1999). Ac-

cording to the new provincial divisions, Rastegar-Pouyani et al. (2006) reported this species from the towns and villages of coastal provinces, including: Sistan and Baluchistan, Hormozgan, Bushehr and Khuzestan. Recently, Gholamifard et al. (2010) recorded *H. flaviviridis* from Fars Province and completed the distribution range in the southern belt of the Iranian Plateau. The previously recorded specimens of *H. flaviviridis* are from "Ghaleh Seied," approximately 25 km northwest of Parishan Lake in Kazeroon Township, western Fars Province (Fig. 1) (Gholamifard et al. 2010). In the present work, a single specimen of *H. flaviviridis* was photographed (Fig. 4) (not collected) on the walls of a house (syntopic with *Cyrtopodion scabrum*), near a mountainous area northeast of the city of Varavi (Mohr Township), in the southwestern region of Fars Province (Fig. 1). This new locality is about 300 km northwesterly from the only previously published record for Fars.

Hemidactylus turcicus (Linnaeus, 1758). Mediterranean house gecko

The type locality of this species is "in Oriente," restricted to Asiatic Turkey (Leviton et al. 1992; Anderson 1999). The Mediterranean house gecko is native to countries surrounding the Mediterranean Sea and extends east to India and south to Somalia. However, *H. turcicus* has spread to several New World countries including Cuba, Mexico, Puerto Rico, Panama, and the United States (Anderson 1999; Farallo et al. 2009). In Iran, it has been collected primarily in port towns of the Persian Gulf, although there are scattered inland records (Shahbazan, Qazvin, Rig Mati) as is also the case in Turkey, Jordan, and Iraq, but all of these localities lie along trade routes (Anderson 1999). In Iran, this species has been recorded from Sistan and Baluchistan, Kerman, Hormozgan, Bushehr, Khuzestan, Ilam, and Qazvin Provinces (Rastegar-Pouyani et al. 2006). Populations of this species in Iran are considered as *H. t. turcicus* (Rastegar-Pouyani et al. 2006, 2008). Both *H. turcicus* and *H. robustus* have been recorded for the herpetofauna of Iran by Rastegar-Pouyani et al. (2008); however, populations of *H. turcicus* in Iran are referred as *H. robustus* by Bauer et al. (2006) as well as Sindaco and Jeremčenko (2008). *Hemidactylus robustus*, of coastal Northeast Africa and Arabia, Iran and Pakistan (Baha El Din 2005; Bauer et al. 2006; Carranza and Arnold 2006), has often been regarded as conspecific with *H. turcicus*, and its complex nomenclatorial history is most recently reviewed by Moravec and Böhme (1997). Carranza and Arnold (2006) in their molecular study confirmed separate status of both taxa. According to their study, *H. robustus* populations from Egypt and the United Arab Emirates show approximately 14% genetic divergence from *H. turcicus*, and the two taxa have recently been found in sympatry on the Red Sea

coast of Egypt (Baha el Din 2005). Iran probably hosts both *H. turcicus* and *H. robustus*. Presumably, populations of *H. turcicus* expanded their distributional range from their area of origin, probably in the Mediterranean region, to northwest of Iran and expanded, or were introduced into other regions of Iran in different ways, and *H. robustus* was introduced via Arabian Peninsula to Iran and expanded in different directions, as its distribution range is completed in the southern belt of the Iranian Plateau. Baha El Din (2005) stated that human activity highly influenced the current distribution pattern of *H. robustus*. As well, Caravan routes had spread *H. turcicus*-like geckos through much of the Middle East (Anderson 1999). However, the presence and definition of exact distributional ranges of these species, in Iran, needs more material and DNA analyses. According to Moravec and Böhme (1997), *H. robustus* differs markedly from *H. t. turcicus* in its robust head, body, and tail, in very small and weakly keeled tail tubercles and in having an inconspicuous color pattern. According to this study, it seems that *H. turcicus* has a smaller distribution range than its congeners in Fars Province.

Presumable routes of distribution of *Hemidactylus* species in Fars Province

Based on the available evidence, *H. flaviviridis* has been reported only from the northwestern regions of Fars Province (Gholamifard et al. 2010). In this survey, as mentioned above, it was recorded from a new locality in the southwestern Fars Province. Since these localities are near the borders with Bushehr Province, and as one of the previously recorded localities of this species, probably southern and western parts of Fars Province are within the natural distributional range of this lizard. As another possible mechanism of distribution, *H. flaviviridis* could have been distributed to Fars Province incidentally via human agency or by destruction and reduction of geographical barriers. The possible mechanisms of distribution, mentioned above, may also be considered for *H. tursicus*. Probably this species colonized Fars Province or expanded its distributional range from the southern provinces (Bushehr and Hormozgan Provinces). Among the three studied taxa here, *H. persicus* has the widest range in Fars Province. The type locality of this species is Iran, but no exact locality was given. Terra typica probably is near Bushehr, Bushehr Province (Leviton et al. 1992; Anderson 1999), and restricted to Shiraz, Fars Province by Smith (1935). With regard to these ambiguities, as one of the possible mechanisms of distribution, *H. persicus* could have expanded its range into Fars Province from Bushehr Province (southwest) or, alternatively, it originated in Fars Province and expanded its range into neighboring provinces in different directions.

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Appendix
Material examined

Hemidactylus persicus (n=12)

CBSU R014, R015: Iran, Fars Prov., SE Darab, Fork [28°17'04.1" N, 55°13'24.1" E, alt. 897 m]. CBSU 4217: Iran, Fars Prov., Jahrom [28°57' N, 53°57' E]. CBSU 5395, 8056.

R009: Iran, Fars Prov., Shiraz [29°37' N, 52°32' E]. CBSU 8055: Iran, Fars Prov., Kazeroon [29°37'6" N, 51°39'30" E]. CBSU 8068, 8071, 8083, 8091, B628 (Re. ex.): Iran, Fars Prov., NW Jahrom Township, Koohe Gorm non-Hunting Area [28°33′ N, 53°6′ E].

Hemidactylus turcicus (n=3)

CBSU R081- 83: Iran, Fars Prov., 25 km NW of Lamerd, Varavi [27° 28' N, 53° 03' E, ele. 421 m].

Hemidactylus flaviviridis (n=3)

CBSU B636, R004, R044: Iran, Fars Prov., Kazeroon, Ghaleh Seied village, 25 km NW Parishan Lake [29°36′15″ N, 51°32′51″ E, ele. 900 m].

Ali Gholamifard earned his B.S. in Animal Biology from the Shahed University of Tehran, Iran, 2005 and his M.S. in Animal Biosystematics from Shiraz University, Shiraz, Iran in 2009, where he studied the reproductive biology of the endemic Iranian cyprinid, Cyprinion tenuiradius Heckel, 1849 under the advisement of Dr. Hamid Reza Esmaeili. His research interests include taxonomy, ecology, biology, conservation, and phylogeography.

Nasrullah Rastegar-Pouyani earned his B.S. in Zoology from Razi University Kermanshah, Iran in 1986 and his M.S. in Zoology from Tehran University, Tehran, Iran in 1991, where he studied herpetology with the agamids as the central object. He started his Ph.D. in Gothenburg University, Sweden in 1994 under the advisement of Professor Göran Nilson and graduated in 1999, working on taxonomy and biogeography of Iranian Plateau agamids with *Trapelus* as the main object. His research interests include taxonomy and biogeography of the Iranian Plateau, the Middle East and Central Asian herpetofauna.

On the occurrence of ectoparasite ticks on *Trachylepis* and *Eumeces* (Reptilia: Scincidae) in Iran

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Abstract.—During field work on the lizards of the Iranian Plateau, it was noticed that some of the lizard specimens were infected by various species of ectoparasitic ticks. In this study the ectoparasites of the scincid lizards of western Iranian Plateau (Zagros Mountains) with regards to their respective parasite loads, especially in *Trachylepis aurata transcaucasica* Chernov 1926, are discussed and compared with the other taxa of the Scincidae, e.g., *Eumeces schneideri princeps* Eichwald, 1839. A total of 70 adult lizards including 12 specimens of *E. e. princeps* and 58 specimens of *T. a. transcaucasica* were examined for tick infection. For the first time, we identified a common tick, *Haemaphysalis parvum* (Ixodidae), in the two above-mentioned lizard taxa. Since prevalence was not 100%, in general, adult lizards host higher tick loads than juveniles and the number of ectoparasites found on abdominal and axial regions in all the infected lizards was between 3-5 per infected host.

Key words. Lizards, ectoparasites, Scincidae, Ixodidae, *Haemaphysalis parva*, Iranian Plateau

Introduction

Parasites comprise a vast diversity of organisms that are specifically adapted to living in or on another living organism (the host). Over 50% of described organisms can be classified as parasites (Price 1980). Reptiles may be infested with a wide variety of ectoparasites, primarily mites and ticks. The study of parasites' effects on their hosts is necessary for conservation of host populations as is an understanding of host ecology. There have been no parasitological studies of lizards in Iran up to now. Blood parasites and gastrointestinal helminthes in different species of lizards have been studied. (Amo et al. 2004, 2005; Ibrahimm et al. 2005). Ticks of the genera *Amblyomma* and *Aponomma* are most commonly found infesting reptiles (McCracken 1994). Lizards are subjected to a number of parasites and unfortunately this has been one of the least studied areas of herpetology, at least in Iran. Several studies have reported that lizard host numbers greatly influence the densities and life histories of their acarine parasites (Norval 1975; Bull 1978; Wilson et al. 1985), and their importance as a critical determinant of lizard distributions is unlikely. The primary aim of this study is to examine and study the ectoparasites of the two scincid lizards, *Trachylepis aurata transcaucasica* and *Eumeces schneideri princeps*. The identified tick species in our materials, *Haemaphysalis parva* Neumann, 1908, belongs to the family Ixodidae.

Materials and methods

This study was carried out during spring and summer 2003-2005 in the western regions of the Iranian Plateau, Zagros Mountains (Fig. 1). In this study we collected 70 lizard specimens belonging to both *Trachylepis* and *Eumeces* in rocky mountains with small shrubs in the form of grassy and herbaceous steppes, and wooded areas where lizards were captured included the common oak *Quercus libani* and *Q. boissieri*. We examined the ectoparasites of lizards with regard to their respective parasite loads. The collected ticks were first photographed in lateral, dorsal, and ventral views using an Olympus loop (Model: SzX12, Japan). Then, by cooperation with the parasitology lab of the faculty of veterinary sciences, Tehran University, the parasites were identified. The identification of parasites was done by using the identification key of Delpy (1938) and Walker et al. (2003). All of the specimens were preserved 70% alcohol and deposited in the collection of the Razi University Zoological Museum (RUZM).

Correspondence. [2]*Email: nasrullah.r@gmail.com*
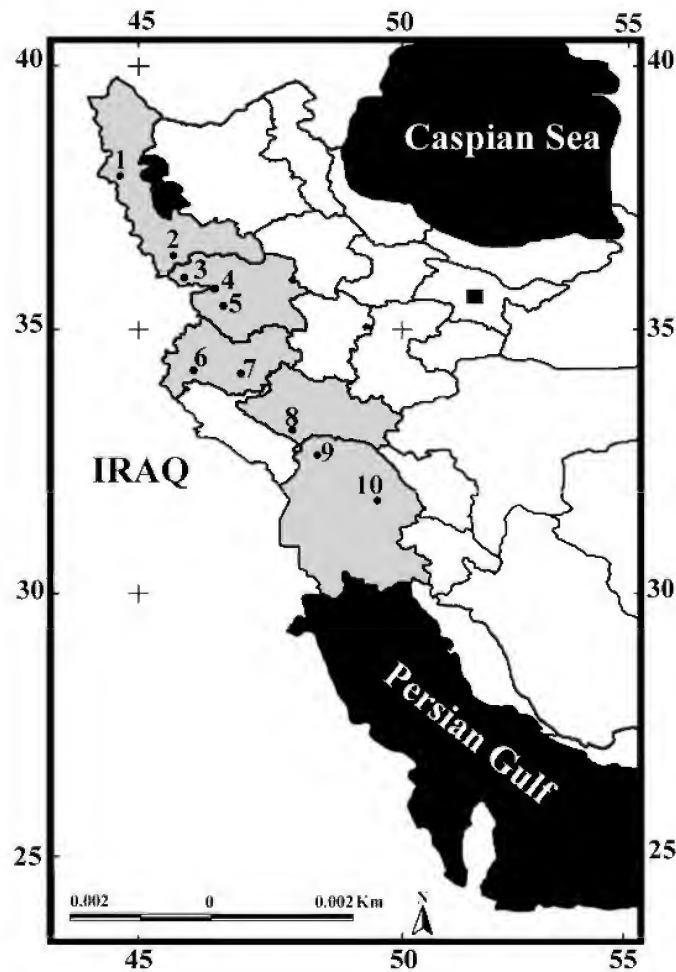
Figure 1. Map of sampling localities (grey areas) for the collected parasites (*Haemaphysalis parva*). (1) Ghotur, (2) Bukan, (3) Baneh, (4) Marivan, (5) Sarvabad, (6) Esalm Abad-e-Gharb, (7) Kermanshah, (8) Poldokhtar, (9) Dezful and Andimeshk, (10) Masjed solaiman and Haft Gel.

Figure 2. *Haemaphysalis parva* (Family: Ixodidae), collected from the underarm region of *Trachylepis aurata transcaucasica* and *Eumeces schneideri princeps*; dorsal (A) and ventral (B) views.

Table 1. Epidemiological indexes of *Haemaphysalis parva* in examined lizards (for details refer to text).

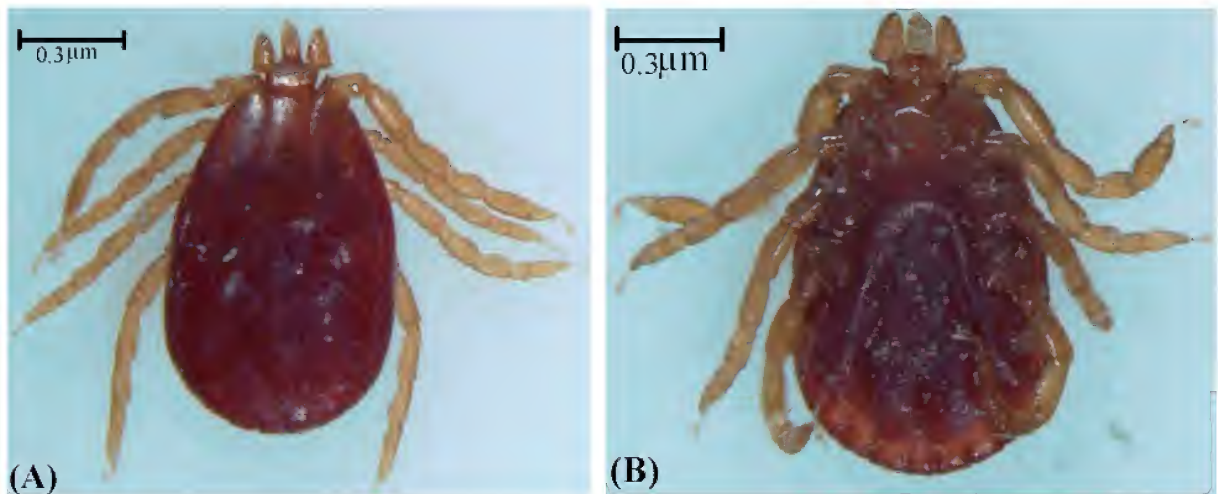| Host species	Class host stage	No. of examined specimens	No. of infected specimens	No. of of ticks on each individual	Prevalence (%)	Mean intensity	Mean abundance
E. schneideri	Adult	9	5	3-5	55.5	3.67	18.35
(*n*=12)	Juvenile	3	1	1-3	33.3	1.33	1
T. a. transcaucasica	Adult	40	18	3-5	45	3.38	60.84
(*n*=58)	Juvenile	18	7	1-3	38.8	1.78	12.46

Results

The number of ectoparasites found on abdominal and axial regions in lizards was between 3-5 for all the investigated lizard species e.g., *E. schneideri* and *T. a. transcaucasica*. The number of larvae, nymphs, males, and females of collected parasites were not considered. Prevalence and infection intensity were higher in adults, and also in larger lizards, than in juvenile lizards (Table 1). In this table, prevalence is expressed in percentage and is the number of individuals of a host species infected with a particular parasite species. Mean intensity is the arithmetic mean, of the number of individuals of a parasite species per host infected, and is counted for each hosted individual (adult or juvenile of each species). Mean abundance is the arithmetic mean, of the number of individuals of a parasite species per host category examined, and was counted for each examined hosted group (in adults or juveniles of each species). These two taxa host a common tick belonging to the genus *Haemaphysalis* (Family Ixodidae), identified as *H. parva* (Fig. 2, A and B).

Discussion

This parasitic tick found on lizards has been recorded for the first time in the western Iranian lizard's fauna. As well, from the view point of geographic distribution, *Haemaphysalis parva* has never been recorded from Kermanshah, Lorestan and Khuzestan Provinces (Telmadarrai et al. 2004).

In our examined specimens, adult lizards were usually carrying greater tick loads than juveniles. Because most parasitological studies in Iran have been carried out by veterinary sections of universities and institutes, almost all the available data in this field are restricted to ticks of paramount importance from view points of health and veterinary medicine, not in the case of lizards, snakes, turtles, and amphibians but for domestic animals. Accordingly, there are records of these ticks on cattle, but not on amphibians and reptiles (Nabian, et al. 2007). Our study is one of the first attempts to determine the ectoparasitic ticks on some lizards of the Iranian Plateau;

the exact degree of impact, of these ticks on their ectothermic hosts, has yet to be revealed. Based on Rahbari et al, 2007, the record is rare for western parts of Iran, and mainly for Kurdistan and West Azerbaijan Provinces. *H. parva* is reported from the Caspian Sea area, in mountainous and semidesert zones, the immature stages are frequently found on small rodents such as social voles (*Microtus socialis*; Filopova et al. 1976).

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Hiva Faizi earned his B.Sc. in plant biology from Shahid Beheshti University (SBU) and his M.Sc. in Animal Biosystematics from Razi University. He is currently employed as a specialist in ecological studies and environment at Mahab Ghodss Consulting Engineering Company. His special interests are morphology, systematics, taxonomy, and biogeography of the Iranian Plateau with special reference to reptiles and amphibians. During his M.Sc. he studied the genus *Trachylepis* in Iran from different perspectives, including morphology, osteology, parasitology, and systematics of *Trachylepis aurata transcaucasica*. Hiva has described a new species of Asaccus lizard, *Asaccus kurdistanensis* with his supervisor Prof. Nasrulla Rastegar-Pouyani and his collaborator Prof. Göran Nilson. Hiva has also studied the near eastern fire salamander, *Salamandra infraimmaculata seminovi*, from Kurdistan province, western Iran. Hiva is collecting data and samples of *Neurergus microspilotus* and *Neurergus kaiseri* to start a Ph.D. project on population genetics and genetic diversity of the two previously mentioned species.

Nasrullah Rastegar-Pouyani earned his B.S. in Zoology from Razi University Kermanshah, Iran in 1986 and his M.S. in Zoology from Tehran University, Tehran, Iran in 1991, where he studied herpetology with the agamids as the central object. He started his Ph.D. in Gothenburg University, Sweden in 1994 under the advisement of Professor Göran Nilson and graduated in 1999, working on taxonomy and biogeography of Iranian Plateau agamids with *Trapelus* as the main object. His research interests include taxonomy and biogeography of the Iranian Plateau, the Middle East and Central Asian herpetofauna.

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SHORT COMMUNICATION

A new record of *Eremias montanus* Rastegar-Pouyani & Rastegar-Pouyani, 2001 (Sauria: Lacertidae) from Kurdistan Province, Western Iran

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Abstract.—During field work in western regions of the Iranian Plateau in the Zagros Mountains, a single specimen belonging to the genus and subgenus *Eremias* Fitzinger, 1834 was collected from the highlands of Badr and Parishan (at about 2466 m elevation) in south of the city of Qorveh, Kurdistan Province, western Iran (47°, 47' E; 35°, 04' N) in July 2010. This is the first record of occurrence of *Eremias* (*Eremias*) *montanus* from Kurdistan Province.

Key words. Lacertidae, *Eremias* (*Eremias*) *montanus*, new record, Qorveh, Kurdistan Province, Iranian plateau, Zagros Mountains

The lacertid lizards of the genus *Eremias* Fitzinger, 1834, encompass about 37 species of mostly sand, steppe, and desert-dwelling lizards which are distributed from northern China, Mongolia, Korea, Central and southwest Asia to southeastern Europe (Rastegar-Pouyani and Nilson 1997; Anderson 1999). This genus is Central Asian in its relationships and affinities (Szczerbak 1974). About 16 species from this genus occur on the Iranian Plateau, mostly in northern, central, and eastern regions (Rastegar-Pouyani and Nilson 1997; Rastegar-Pouyani and Rastegar-Pouyani 2001; Anderson 1999).

As a member of this genus, *Eremias* (*Eremias*) *montanus* is distributed in western Iran, in Kermanshah and Hamadan Provinces (Rastegar-Pouyani and Rastegar-Pouyani 2001, 2005; Rastegar-Pouyani, N. et al. 2006, 2007; Rastegar-Pouyani, E. et al. 2009).

So far, there are no further records of occurrence of *Eremias* (*Eremias*) *montanus* in other regions of the Zagros Mountains, including Kurdistan Province, which is located on the western periphery of the Iranian Plateau, bordered by Iraq on the west (Fig. 1). In July 2010, we collected a single specimen of this taxon from the highlands of southern Kurdistan Province from the Badr and Parishan region, about 20 km south of Qorveh city near the Aminabad village (47°, 47' E; 35°, 04' N; 2466 m).

The collected specimen was active during the daytime, foraging on rocks and in rock crevices as well as under bushes. The habitat is an upland area, characterized by steppe vegetation, being covered with snow from late November until late March (in the snow covered years) (Fig. 2).

Measurements in millimeters (mm) and pholidotic characters, as well as color pattern of the collected specimen, are as follows:

Snout-vent length (SVL) 59.5; tail length 95.5; axilla-groin distance 26; foreleg length 22.8; hind leg length 37.4; head length 20; head width 11; head height 5.27; dorsal scales slightly converging posteriorly with 65 small granular scales across middle of dorsum; venter with 13-14 longitudinal and 27-28 transverse rows of plates; subocular reaches mouth edge; one frontonasal; two supraoculars which are not completely separated from frontal and frontoparietals; 14 scales across widest part of venter; lower surface of the fourth finger containing two rows of subdigital scales; the lateral scales of the fourth finger without carinate lamellae; 25-26 scales on the 11th annulus of the tail; 8-9 upperlabials, 4-5 of which anterior to subocular; 7-8 lower labials; two supraoculars; 6-7 supracilliaries; 20-20 femoral pores, separated by three scales; 11-12 collars; five pairs of submaxillary shields.

Coloration: the collected specimen is an adult male, dorsum dark-brown almost without spots and ocelli, interrupted by five light longitudinal stripes, the vertebral

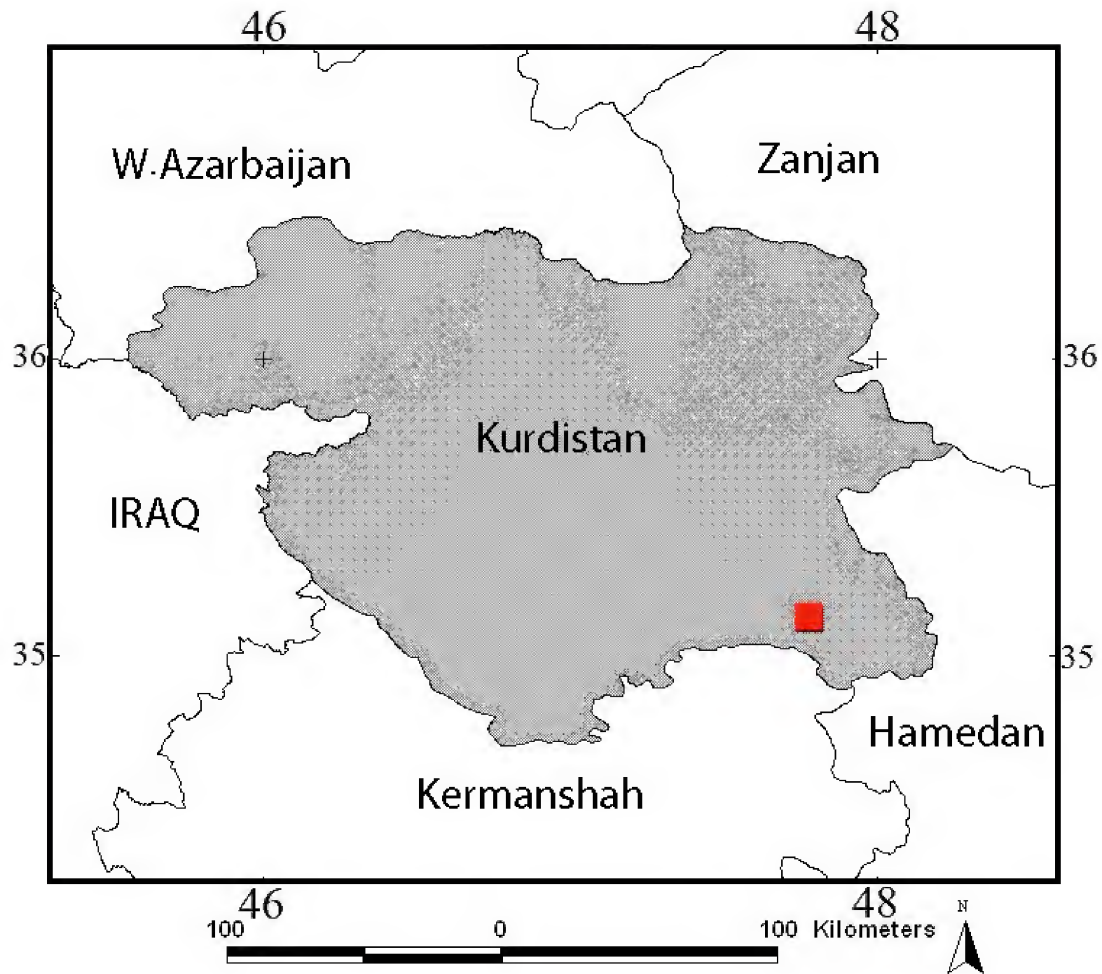**Correspondence.** [2]*Email: nasrullah.r@gmail.com*

Figure 1. The red square is the location of the newly-collected specimen of *E.* (*Eremias*) *montanus* in Kurdistan province.

Figure 2. The natural habitat of *Eremias* (*Eremias*) *montanus* (new record) in Badr and Parishan highlands, at about 2466 m elevation.

Figure 3. Dorsal view of the collected specimen of *Eremias* (*Eremias*) *montanus*.

stripe bifurcating on the nape, a single paravertebral stripe on each side and two dorsolateral stripes containing light spots; venter dirty-white; the proximal lower caudal region being whitish-gray, becoming lighter distally. The collected specimen is preserved in 75% alcohol and is deposited at the collection of the Razi University Zoological Museum (RUZM-LE30.7) (Fig. 3).

Remarks: *Eremias* (*Eremias*) *montanus* was first described in 2001 from the highlands of Kermanshah Province, western Iran at an elevation of more than 2000 m (Rastegar-Pouyani and Rastegar-Pouyani 2001). This lizard belongs to the mountainous radiation of the *Eremias persica* species complex inhabiting high elevations of the Zagros Mountains (Rastegar-Pouyani, E. et al 2009). In 2005, Rastegar-Pouyani and Rastegar-Pouyani reported a new and unknown population of *Eremias* from the high elevations (about 2800 m above sea level) of the Alvand Mountains in Hamedan Province. These authors tentatively named the new population as *Eremias novo* (Rastegar-Pouyani and Rastegar-Pouyani 2005). With further morphological and molecular studies it was shown that this new population is conspecific with *Eremias* (*Eremias*) *montanus* (Rastegar-Pouyani, E. et al. 2009). Thus, the original range of the species extended into highlands of Hamedan Province, some 175 km toward the south.

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Ahmad Gharzi graduated with an M.Sc. degree in Animal Biology from Tehran University, where he worked on lizard faunas of eastern Iran. Ahmad later received a Ph.D. from Durham University, UK, in Developmental Biology and is now an academic staff at Lorestan University, Iran. His interests involve different aspects of biology including histology, developmental biology, and taxonomy.

Sexual dimorphism in *Trapelus ruderatus ruderatus* (Sauria: Agamidae) with notes on the natural history

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Abstract.—We studied sexual dimorphism and some aspects of natural history and behavior of the Persian agama (*Trapelus ruderatus ruderatus*) from a population in Dehloran Township, Ilam Province, southwestern Iran. Findings were obtained by personal observations and using SPSS 13 statistical package. Based on the analyses, some characters show differences between males and females. All findings for *T. ruderatus* in this paper are reported for the first time.

Introduction

The genus *Trapelus* Cuvier, 1816, comprises four species on the Iranian Plateau as follows: *T. agilis* (Olivier 1804), *T. lessonae* (De Filippi 1865), *T. ruderatus* (Blanford 1881) (*sensu* Rastegar-Pouyani 2000) and *T. megalonyx* (Günther 1865). The distribution of *T. ruderatus* in Iran is limited to southern and southwestern regions of the Iranian Plateau (Anderson 1999; Rastegar-Pouyani 2000; Fathinia 2007; Rastegar-Pouyani et al. 2008). Among the Iranian species of the genus *Trapelus* the study of sexual dimorphism has already been carried out in *Trapelus agilis* (Rastegar-Pouyani 2005). In this relation, study of sexual dimorphism, coloration and color pattern, and natural history of the Persian agama (*Trapelus ruderatus*) is of interest and importance.

As genetic correlation between the sexes is very high for most morphological traits, it is often believed that long periods of time are required to overcome genetic constraints and to evolve sexually dimorphic morphological traits (e.g., Lande 1980; Hedrick and Temeles 1989; Kratochvíl et al. 2003). Moreover, the evolution of sexual dimorphism may be limited by physiological and ecological constraints as well (Kratochvíl et al. 2003).

In agamid lizards, both sexual selection and natural selection influence the form of dimorphism in secondary sexual traits (Stuart-Fox and Ord 2004). Sexual dimorphism (SD) in body shape as well as overall body size is a widespread and common trait among animals (Ji et al. 2006; Kaliontzopoulou et al. 2007), most species being dimorphic rather than monomorphic (Schoener 1977; Mouton and van Wyk 1993; Andersson 1994). Different evolutionary mechanisms have been proposed for the de-

velopment of sexual dimorphism in various animal taxa. However, most of these mechanisms can be summarized by three major forces differentially acting on males and females of a population: sexual selection, fecundity, and natural selection (Olsson et al. 2002; Cox et al. 2003). In many taxa, competition between males over resources characteristically produces an asymmetry in body size between the sexes. Thus, the advantages of larger size for males typically results in sexual size dimorphism (SSD) (Terry et al. 2001). Sexual selection acts on competition between males, often resulting in larger body size and in larger sizes of morphological structures related to fight (Darwin 1874; Verrastro 2004). Anderson and Vitt (1990) suggest that the causes of sexual dimorphism in size could be related to several factors: competition between males; differential mortality between sexes due to differences in longevity; larger amount of energy allocated by females for reproduction; males are more active because they need to search for females and thus present a larger predation risk.

In this paper, the patterns of sexual dimorphism in the Persian agama, *T. ruderatus*, in relation to environmental issues are discussed.

Materials and methods

This survey was carried out in Dehloran area at an elevation of 202 m, approximately 5 km around the city of Dehloran, Ilam Province. The coordinates of study site are 33.5°39′N, and 45°18′E. The information was accessed by a GPS model Etrix. The study area has an annual precipitation of 244.2 mm, and an annual average maximum

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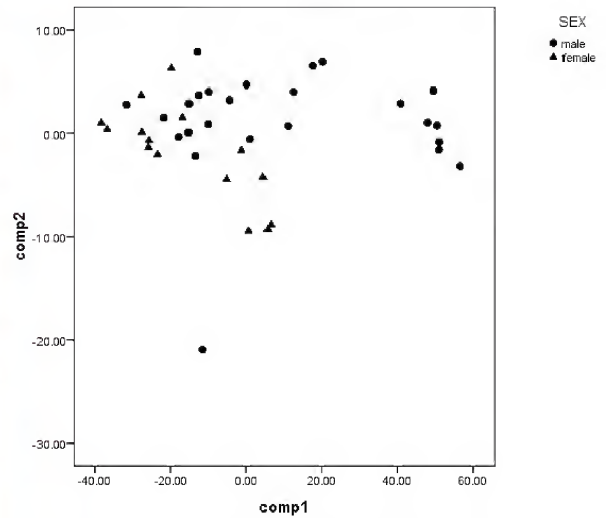
Figure 1 (left). Dorsal view of a male (right) and a female (left) of *Trapelus r. ruderatus*.

Figure 2 (above). Ordination of the individual males and females of *Trapelus r. ruderatus* on the first two principle components. Note the relative degree of isolation of males and females.

Figure 3. The color pattern of an adult male *T. ruderatus* during the hottest hours of the day.

Figure 4. An adult male *T. r. ruderatus* capturing a spider while foraging.

Figure 5. The occurrence of *T. r. ruderatus* with *Uromastyx loricatus* in the same hole.

Table 1. The comparison of 16 characters in males and females of *Trapelus r. ruderatus*. SEM: standard error of mean; D. of d.: Direction of difference; M. of d.: Mean of differences. All measurements in millimeters (mm).

SEX		IL	IN	NP	SDL	SVL	TL	HL	RP	SL	SBEH	LFL	LHL	LFH	VL	HW	CT
♂	Mean	16.84	5.76	8.48	21.48	85.95	127.25	21.66	1.16	18.08	15.48	31.68	44.91	42.64	8.75	19.10	15.92
	N	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25	25
	SEM	0.27	0.24	0.78	0.36	2.75	4.40	0.66	0.11	0.24	0.48	1.35	1.19	1.8	0.37	0.61	0.282
♀	Mean	16.06	5.73	2.86	21.33	76.05	106.8	19.53	0.40	16.40	15.20	27.32	39.59	37.57	6.54	17.54	13.86
	N	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15	15
	SEM	0.37	0.36	0.76	0.42	2.82	2.38	0.66	0.1393	0.45	0.35	0.87	0.97	1.72	0.3	0.6	0.29
	M. of d.	0.78	0.03	5.62	0.15	9.9	18.85	2.13	0.76	1.68	0.28	4.36	5.32	5.07	2.21	1.56	2.06
	D. of d.	M>F	M>F	M>F	M>F	M>F	M>F	M>F	M>F	M>F	M>F	M>F	M>F	M>F	M>F	M>F	M>F

and minimum temperature of 31.6°C and 17.8°C, respectively (Abdali 2009). The study area classified as open habitat based on Stuart-Fox and Ord (2004) which is a semi-desert, alluvial fan area. A total of 40 adult specimens of *T. r. ruderatus* (25 males, 15 females) were examined in this survey. Of these, three were borrowed from RUZM (Razi University Zoological Museum, Kermanshah) while the 37 remaining specimens were collected during September 2008 to September 2009 in the study area. Many of the specimens (12 males and 8 females) were dissected to determine sex and then preserved for further studies. The largest male and female were 111.76 mm and 92.72 mm SVL, respectively. The 17 remaining specimens were caught, measured, and released in the study area. Measurements included 16 metric and meristic characters, based on Rastegar-Pouyani (1999, 2005) and Torki (2007). The metric characters included: SVL: snout-vent length, from end of mental to cloaca; TL: tail length, from cloaca to tip of tail; HL, head length, from end of rostral to anterior border of ear opening; HW: maximum head width; LFL: length of fore limb; LHL: length of hind limb; LFH: length between fore limb and hind limb, from axil to groin; VL: vent length.

The meristic characters included: CT: crossbars on dorsal side of tail; IL: number of infralabial scales; SL: number of supralabial scales; SBEH: scales between eyes across head; SDL: subdigital lamellae under the fourth toe; IN: number of internasals; NP: number of preanal callose scales; RP: rows of callose preanal scales. The metric and meristic characters were measured in mm to the nearest 0.01 mm using digital caliper model Shoka Gulf and/or stereomicroscope. To test the significance of sexual dimorphism, the ANOVA test as well as the Principle Component Analysis (PCA: correlation matrix) were employed. The SPSS software version 13 was used for carrying out the statistical analyses. In addition to the study of sexual dimorphism, some aspects of the ecology of the species including color pattern and color changes of concealed and exposed body regions, behavior, and habitat type and vegetation were considered carefully. According to Stuart-Fox and Ord (2004) the lateral regions of the head, the throat, chest and ventral regions were regarded as "concealed," whereas the remaining body regions were considered as "exposed." Plant species were determined based on "Flora of Ilam" (Mozaffarian 2008).

Results

Statistical analysis

A summary of the 16 measured characters is shown in Table 1. There are obvious differences between males and females for 10 characters NP, SVL, TL, HL, RP, SL, LFL, LHL, VL, and CT. For all the significant characters the males have greater values than females. Based on this

Table 2. Extraction of principle components 1-4 using the component matrix.

Characters	PC1	PC 2	PC 3	PC 4
IL	0.239	0.575	-0.355	0.239
IN	-0.402	0.450	0.586	0.032
NP	0.715	0.370	-0.175	-0.322
SDL	-0.086	0.410	0.180	0.666
SVL	0.960	-0.206	0.096	-0.022
TL	0.955	-0.062	0.015	-0.043
HL	0.910	-0.204	0.264	-0.056
RP	0.542	0.648	-0.028	-0.205
SL	0.356	0.747	0.100	0.303
SBEH	-0.221	0.256	0.781	-0.372
LFL	0.601	-0.274	0.186	0.241
LHL	0.967	-0.070	0.006	0.110
LFH	0.937	-0.233	0.015	0.032
VL	0.877	0.201	0.088	0.075
HW	0.925	-0.255	0.156	0.054
CT	0.320	0.646	-0.269	-0.377

study, in most cases the color pattern in females is paler than in males (Fig. 1).

The results of a PCA performed on *T. r. ruderatus* are summarized in Table 2. With 16 variables there are 16 principle components. Details of the first four principle components are given in Table 3. As is shown, the first four principle components (PC1-PC4) account for 48.57%, 16.41%, 8.57%, and 6.94% of the total information, respectively. Jointly they explain 80.45% of the total information.

In the PC1 which contains 48.57% of the total information, the characters NP, SVL, TL, HL, LHL, LFL, VL, and HW having greater values, hence having more contribution and importance in sexual dimorphism. The PC1 highlights a size (metric) difference. The scores of the males along this axis (Fig. 2) show an overlap with those for females, indicating that although sexual dimorphism occurs between males and females, the two sexes are not completely separated from each other in these characters.

The second axis (PC2) contains 16.41% of the total variation and is a meristic axis that records individuals at one end with relatively large IL, NP, RP, SL, and CT and small SVL, HL, LFL, LFH, and HW, compared with individual with relatively small IL, NP, RP, SL, and CT and large SVL, HL, LFL, LFH, and HW.

The third axis (PC3) contains 8.57% of the total variation, and is a meristic axis that records individuals at one end with relatively large IN and SBEH and small

IL and CT, compared with individuals at the other end with relatively small IN and SBEH and high values for IL and CT.

The fourth axis (PC4) contains only 6.94% of the total difference, highlighting a meristic axis showing individuals at one end with relatively large SDL and small CT, SBEH, and NP, compared with individuals at the other end with small SDL and large CT, SBEH, and NP.

Color changes

The Persian agamid, *T. r. ruderatus*, changes its color and adjusts itself based on environmental requirements. During hot hours of the day, the dorsal color of *T. ruderatus* turns to paler in comparison to the cooler hours. During the hot hours, the vertebral stripe becomes lighter, dorsal regions of the body and tail and temporal regions turn to brick, color of flanks becomes vinous and ventral surfaces of body and head turn to whitish (Fig. 3).

The brick color of the dorsal region of tail is more conspicuous than the rest of the body. Color changes look more prominent when a lizard is alarmed. When frightened, the lizard stands on forelimbs, protrudes gular fold and gets ready to bite. The case is true for both males and females. During this defensive posture, the dorsal region of the tail turns brick red while flanks, gular fold, lower surfaces of the eyes, and upper surfaces of limbs (especially the forelimbs) turn to dark blue (Fig. 4). The specimens that collected during September were lighter in color than those collected in April. It seems that so far color changing during reproductive season have not yet been documented for *T. r. ruderatus*, hence this case needs further investigation.

Natural history

The specimens were observed and collected in different habitats, including sandy areas, alluvial fans, and gravel areas in alluviums. *Trapelus ruderatus* occupies territories with special plants and bushes including *Alhagi camelorum, Malva parviflora, Ziziphus numularia, Capparis spinosa, Chrozophora tinctoria*, and hand-planted trees such as *Prosopis juliflora*. Most specimens were collected during the hot hours of midday under *C. tinctoria. Trapelus ruderatus* is sympatric with *T. lessonae* in

Table 3. Total variance for the first four principle components. Extraction method: Principle Component Analysis.

	Initial Eigenvalues			Extraction Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
PC1	7.772	48.575	48.575	7.772	48.575	48.575
PC2	2.626	16.411	64.986	2.626	16.411	64.986
PC3	1.371	8.570	73.555	1.371	8.570	73.555
PC4	1.105	6.904	80.459	1.105	6.904	80.459

the Dehloran region. Some individuals make holes under aforementioned plants and others use deserted holes of other reptiles or rodents. *Trapelus ruderatus* sometimes lives with *Uromastyx loricatus* in the same hole (Fig. 5). Moreover certain species of reptiles, some arthropods such as members of the family Gnaphosidae (ground spiders) were observed during excavation of a hole of *T. ruderatus*. It seems that *T. ruderatus* depends strongly on the aforementioned vegetation, as they: A) provide shelter against predators, B) provide shadow during hot summer mid days, C) attract specific types of arthropods and D) serve as ambush for prey. In one case, the senior author found an adult *T. ruderatus* on *C. spinosa* a distance from its burrow of more than 20 meters. This may be indicative of the importance of vegetation in the life history of this lizard. *Trapelus ruderatus* is usually territorial but in one case two adult male specimens were observed under the same *Z. numularia*; both were collected while the tail of the smaller specimen was bitten by the larger one.

Discussion

Sexual size dimorphism is the evolutionary result of selection operating differently on the body size and other characters of males and females (Andersson 1994, Torki 2007). Sexual and/or natural selection can act on both sexes, resulting in the morphological patterns. Genetic correlations between the sexes, as well as phylogenetic inertia, could be factors affecting the observed morphologies (Kaliontzopoulou et al. 2007). Although direct sexual selection can have a major role in the evolution of neomorphic structures, sexual differences are often related to allometric patterns and heterochronic processes (Bruner et al. 2005). Sexual dimorphism is widespread in lizards, with the most consistently dimorphic traits being head size (males have larger heads) and trunk length (Torki 2007). The case is true for *T. r. ruderatus*. Since head dimensions are directly related to bite force, it seems likely that bite force, through its effect on dominance, is a performance trait under sexual, and also, natural selection. Bite force is decisive in species that engage in physical combat (Huyghe et al. 2005). Theoretically, fecundity selection favors large females and sexual selection favors larger males. The two selective pressures could cancel each other out and, consequently, result in a lack of SSD between males and females. For example, selection via male contest competition is the ultimate factor resulting in increased male size in *Eumeces chinensis* and *E. elegans*, whereas selection acting on fecundity or litter mass is the main cause for increased female size in *Phrynocephalus vlangalii* (Ji et al. 2006). So the male contest may be the main pressure resulting in larger SVL in the males of *T. r. ruderatus*. Both sexes have evolved different body or head sizes to use different niche dimensions, such as habitat type, perch height, or diet ("intraspecific

niche divergence" hypothesis) (Smith and Nickel 2002). This may explain the larger HL observed for males in *T. r. ruderatus*. Sexual dimorphism can also be observed in forelimbs and hindlimbs. Long limbs increase maximum sprint speed, allowing lizards to catch prey or escape predators more efficiently. However, shorter limbs are favored on narrow perches because they enhance agility relative to longer limbs (Calsbeek and Smith 2003). Females, on the other hand, have to cope with the functional challenges posed by egg bearing (Butler and Losos 2002). Males tend to have larger limbs which can increase sprint for an escape from predators or facilitate chasing females for successful mating (Fathinia 2007). Sexual selection for effective territory defense has favored males that are more likely than females to stand their ground when approached by a predator and that this decreased wariness led to predator-mediated natural selection for longer legs and concomitant greater speed in males (Peterson and Husak 2006). Taken together, the mentioned reasons may explain sexual dimorphism in the limbs of *T. r. ruderatus*. The longer tail was assumed to be the result of morphological constraints imposed by the male copulatory organs on tail autotomy, or it may have evolved as a result of improved escape abilities in the sex more likely subjected to heavier predation pressure (Kratochvíl et al. 2003). Males are territorial and large size enhances male reproductive success (Shine et al. 1998). This may explain the longer tail and trunk in the male Persian agama.

Epidermal glands in the cloacal or femoral regions of many lizards have semichemical function related to sexual behavior and/or territorial demarcation. Signals are passively deposited in the environment during locomotion of the animals within their territory (Imparato et al. 2007). Most males are aggressive, territorial, and male territories can contain several female home ranges. One advantage of chemical signals is that they can be used to obtain information about an individual even when other sensory cues are absent. Thus, females might choose where to establish their home ranges by relying on information coming from the chemical signals left from territorial males (Martin and Lopez 2000).

Animal color patterns have received significant attention from different fields, including ecology, physiology and systematics. One of the main generalizations reached is that color patterns constitute adaptive evolutionary characters, representing a compromise between two main selective forces, sexual and natural selection. In reptiles, sexual selection through female mate choice and/or male-male competition, usually determines the occurrence of colorful males particularly during the reproductive season; females can choose males based, among others, on visual displays in which color patterns are highly relevant. Natural selection acts through predation and thermoregulation. Thus, diurnal reptiles exposed to visual predators experience an intense selection for substrate matching to diminish their vulnerability to these predators. On the other hand, dark colors, which

absorb more heat, occur with higher frequency in animals from environments with lower temperature (Vidal et al. 2007).

Two primary processes may drive the evolution of color change: (1) natural selection for the ability to camouflage (crypsis) against variety of backgrounds and (2) selection for conspicuous social signals. In many color-changing lineages, color change is known to facilitate both crypsis and social communication (Stuart-Fox and Moussalli 2008). It seems that dichromatism of "exposed" body regions is significantly associated with habitat openness: species occupying open habitats are less sexually dichromatic than species in more closed habitats (Stuart-Fox and Ord 2004). The case is true for *Trapelus ruderatus*. Dichromatism of "exposed" body regions is constrained by natural selection, whereas dichromatism of "concealed" body regions is driven by sexual selection. According to predation hypothesis, species occupying open habitats are more vulnerable to visual predators. In the species which live in open habitats both sexes are cryptic and therefore less dichromatic (Stuart-Fox and Ord 2004). This case is observed in both males and females of *T. ruderatus*. Based on the predation hypothesis the extent of sexual dichromatism is related to habitat openness only for body regions exposed to visual predators. Concealed body regions have important roles in intraspecific communication, for example most agamid species flash dewlaps or perform head bobs in social interactions (Stuart-Fox and Ord 2004). Regarding the fact that the Persian agama is an open habitat dweller, aforementioned strategies (natural selection for crypsis, selection for conspicuous social signals, and the predation hypothesis) may explain the relatively weak dichromatism observed in both males and females of this lizard.

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Appendix
Material examined

Trapelus ruderatus ruderatus (*n*=3): RUZM-AT.12.1 to RUZM-AT.12.3: Iran, Fars province, Lamerd, 20 km south of Lamerd [27° 20′N, 53° 10′ E]. RUZM-AT.12.4 to RUZM-AT.12.23 (*n*=20): Iran, Ilam province, Dehloran township [33.5°39′ N, 45°18′E; 202 m above sea level].

Trapelus ruderatus ruderatus (*n*=17): Examined and then released in the study area.

Behzad Fathinia earned his B.A. and M.S. from Isfahan and Lorestan universities, respectively. His M.S. reaserch focused on "The Biosystematic Study of Lizards of Ilam Province." For the time being, he is a Ph.D. student at Razi University, Kermanshah, western Iran under supervision of Nasrullah Rastegar-Pouyani, Mozafar Sharifi, and Eskandar Rastegar-Pouyani. His dissertation research involves ecology, phylogeography, molecular systematics, and population genetics of the Iranian viper *Pseudocerastes urarachnoides* in western Iran. He is also interested in other reptiles, specially snakes.

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A new species of *Ophiomorus* (Squamata: Scincidae) from Maranjab Desert, Isfahan Province, Iran, with a revised key to the genus

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Abstract.—A new species, *Ophiomorus maranjabensis*, is described from Maranjab in the Kavir Desert in Iran. This new species is distinguished from other three-fingered, three-toed species by having parietals in contact posteriorly; prefrontals not in contact with upper labials, 22 scale rows at midbody, a large fifth supralabial, and a long preocular. A revised key to the genus is presented.

Key words. New species, *Ophiomorus*, Iran, Isfahan Province, Maranjab, habitat

Introduction

The nocturnal burrowing skinks of the genus *Ophiomorus* have been collected less often than most other lizards in Iran. The first revision of the genus was that of Boulenger (1887) and not reviewed again until 1966 when Anderson and Leviton (1966) undertook the task and added an additional three species. They recognized an eastern group of the genus inhabiting the desert areas from Iran through southern Afghanistan and Pakistan to the Punjab, and a western group extending through the more mesic areas from Greece to the Zagros Mountains of Iran. These authors provided diagnoses and synonymies for all then-known species. Anderson (1999) summarized the Iranian species following the description of another species from the Iranian Plateau, *O. nuchalis* Nilson and Andrén 1978. A phylogenetic cladistic analysis was published by Greer and Wilson (2001). Their analysis confirmed *Ophiomorus* as a monophyletic genus and the eastern species clade as monophyletic. The western group of species was judged, somewhat tentatively, as polyphyletic in origin.

Three specimens of *Ophiomorus* were collected by Masood Farhadi Qomi and Seyed Mahdi Kazemi on 17 May 2011, in the Maranjab, south of Daryache Namak (salt lake), north of Isfahan, Iran. This site is situated about 52 km southwest of the type locality for *O. nuchalis*, the westernmost known species of the desert group.

Our specimens differ distinctly from other three-fingered species in several morphological aspects, and we here describe it as a new species.

The new species brings the number of species in the genus to 11. The genus is distributed from Greece to western India (see Sindaco and Jeremcenko 2008, for spot maps of all known museum specimens and published locality records of the genus).

Diagnosis of the genus *Ophiomorus* (from Greer and Wilson 2001)

The genus *Ophiomorus* may be diagnosed *vis-a-vis* the generally primitive scincid genus *Eumeces* on the basis of the following derived character states: nostril between an upper and lower nasal scale, both of uncertain homology …; prefrontal scales separated; frontal scale hour-glass shaped due to constriction of frontal by first supraocular (except in *O. latastii* …) …; supraoculars three (as opposed to four); supraciliary row incomplete lateral to most posterior supraocular, i.e., most posterior supraocular enters supraciliary row: frontoparietals separated;

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pretemporal single: lower eyelid with clear central disc; postsupralabial single; postmentals two (variable in *Eumeces*, hence possibly primitive in skinks): dorsal and lateral body scales with one or sometimes two (in tandem) minute pits in central posterior part of scale; digits 4/3 or less and phalanges 2.3.4.2/2.3.4 or less; premaxillary teeth modally < 6; presacral vertebrae > 45; sternal/mesosternal ribs < 3/l; inscriptional chevrons > 7…; thoracic and sometimes anterior lumbar ribs with dorsoanterio accessory processes.

Ophiomorus maranjabensis Kazemi, Farhadi Qomi, Kami and Anderson

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Holotype: ZMGU (Zoological Museum Gorgan University) 2570, an adult female from Maranjab, south of Daryache Namak, Iran, N 34°19'52.78", E 51°53'20.44". Collected 17 May 2011 by M. Farhadi and S. M. Kazemi.

Paratypes: ZMGU 2571 and 2572, adult females, from Maranjab, about 1 km southwest of holotype, N 34°18'56.50", E 51°52'45.15".

Diagnosis

An *Ophiomorus* with three fingers, three toes; distinctly enlarged nuchals; snout bluntly spatulate; interparietal broader than long; frontonasal septagonal; six supralabials, the fifth, greatly enlarged, below the eye. Parietals in contact behind interparietal; nuchals in contact behind parietals. Preocular very large, about two-thirds distance between eye and nostril, and in contact with third, fourth, and fifth supralabials. Twenty-two scales round the middle of the body.

Description of holotype (ZMGU 2570)

Head depressed; snout cuneiform, with sharp angular labial edge; mouth inferior. Rostral with a triangular, convex, superior portion equal in length to two-thirds the width, the inferior portion slightly concave, lying entirely in front of the mouth, and equal in length to about two-thirds the width; the posterior angle of the rostral does not partially separate the supranasals; frontonasal septagonal, two thirds as broad as long, twice as long as the suture formed by the supranasals; frontal ten-sided, broader than long, interparietal slightly broader than long, equal with frontal, its straight anterior border forming a broad suture with the straight posterior border of the frontal; a pair of elongate, curved parietals, about one-third as

broad as long, obliquely arranged, meet behind the interparietal to form a short suture; a pair of enlarged nuchal shields, in contact behind parietals. Nostril in the suture between the nasal and the supranasal, narrowly separated from the rostral: nasal three-fourths the length of the supranasal, as high as long; supranasal broader than long; prefrontals quadrangular and elongate, in broad contact with preocular, not in contact with supralabials; preocular very large, about two-thirds distance between eye and nostril, and in contact with third, fourth, and fifth supralabials; loreal as high as long, smaller than the preocular, three small supraoculars, size is 2 > 1 > 3; no frontoparietal; four or five elongate supraciliaries on each side; upper eyelid rudimentary; lower lid with a larger transparent scale, two postoculars. Six supralabials, fifth is very large, presumably as a result of fusion with the supralabial behind it, twice or more the size of adjacent labials and in contact with eye, postocular and preocular (below the eye, postocular and preocular), the 1st much smaller. No ear opening. Parietal eye not discernable.

Three toes, three fingers. Four scales on longest finger, seven scales on longest toe.

Mental quadrangular, the posterior border concave; two azygous postmentals, the posterior (second) much larger, first postmental in contact with first pair of sublabials, second postmental in contact with first, second, and third pairs of sublabials; a series of three enlarged shields on either side of the chin, bordering the infralabials, six supralabials, six sublabials.

The tail is broken approximately at one half its length, and the broken part has been retained.

Color pattern

As in most of the eastern species, dorsal ground color golden tan, venter cream-white without markings. A dark stripe runs from nostril through eye along the length of body and tail. A dark roughly Y-shaped mark on the frontal and prefrontal; an approximately L-shaped mark on the front and center of the interparietal and a spot on the posterior part of that scale, ill defined spots on parietals and nuchals. Each paravertebral scale with a dark spot, these coalescing to form two dark lines down body onto tail, where they break up into lines of discrete dots that run the length of tail; two dorsolateral lines of discrete dots on either side of body and tail (Table 1; Figs. 2-5).

Paratype (ZMGU 2571): same as holotype, except a series of four enlarged shields on either side of the chin. Parietal eye visible in interparietal.

Paratype (ZMGU 2572): same as holotype, except third supralabial scale smallest, scales of second and forth in contact with each other on the right side. Parietal eye visible in interparietal.

Figure 1. Places of specimen collection: black diamond, type locality of *Ophiomorus nuchalis* Nilson and Andrén, 1978; blue circle, type locality of *Ophiomorus maranjabensis* from Maranjab.

Figure 2. Live specimen. Holotype of *Ophiomorus maranjabensis* (ZMGU2570).
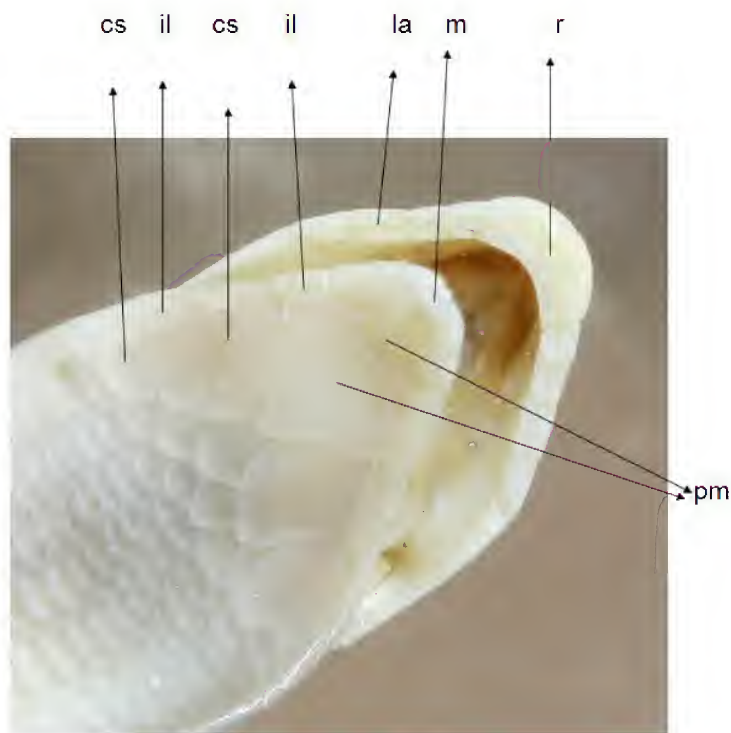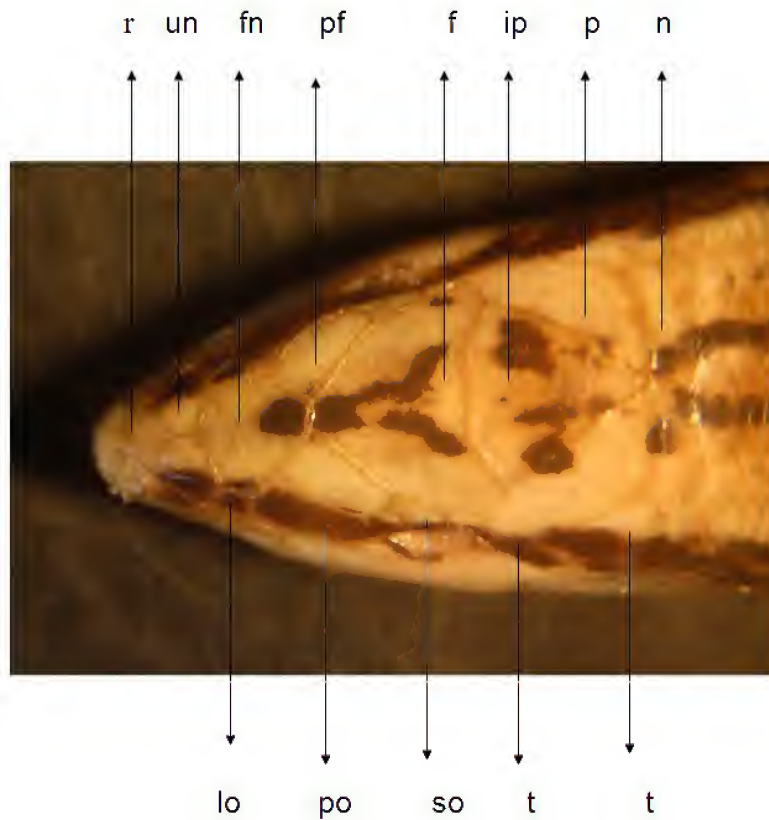
Figures 3a and 3b. Head scale nomenclature for *Ophiomorus maranjabensis*: cs – chin scale; fn–frontonasal; il – infral-abial; ip – interparietal; la --upperlabial; lo – loreal; m – mental; n – nuchal; p – parietal; pm – postmental; po – preocular; ps – postsupralabial; r – rostral; so – supraocular; t – temporal; un – upper nasal.

Figure 3c. Head scale nomenclature for *Ophiomorus maranjabensis*: cs – chin scale; fn–frontonasal; il – infralabial; ip – interparietal; la --upperlabial; lo – loreal; m – mental; n – nuchal; p – parietal; pm – postmental; po – preocular; ps – postsupralabial; r – rostral; so – supraocular; t – temporal; un – upper nasal.

Figure 4. *Ophiomorus maranjabensis*, forelimb.

Figure 5. *Ophiomorus maranjabensis*, hindlimb.

Distribution

Known only from the holotype and paratypes (Map, Fig. 1). Gören Nilson (pers. comm.) reports finding tracks of an *Ophiomorus* (Fig. 7) in large numbers in a nearby region of the Kavir, Central Province, east of Abu Zeidabad at N 33°58'7.36", E 51°98'9.77" on 7 June 2000. They spent one night searching for it unsuccessfully. He was convinced, at the time, that it must have been an undescribed species, because the sand dune habitat was very different from that of *O. nuchalis* habitats, and geographical distance from other species. See Greer and Wilson (2001) for comparative characters and measurements for all species of the genus.

Habitat

The type locality is in the Maranjab, north of Isfahan, Iran, situated south of salt lake (Daryache Namak).

Average yearly precipitation is 170.69 mm at the nearest meteorological station in Kashan, about 55 km to the southwest. During the hot summer months the mean recorded summer maximum air temperature is 40.39°C and the mean minimum winter temperature 0.54°C. The highest recorded temperature was 46°C, and a minimum temperature of -9°C. The collection site is in the lower hills at the southern border of the salt lake, about 185 km north of Isfahan.

The vegetation is low density. The vegetation includes *Alhagi*, Boraginaceae, *Heliotropium aucheri*, *Peganum harmala*, Poaceae, and *Rosularia*. Soil loose sandy, similar to substratum where other three-fingered, three-toed species of the genus are found.

Natural History

The specimens collected were found at night in pitfalls. ZMGU 2571 was dead, probably owing to the daytime heat in the pitfall. Other reptile species, observed in the same habitat and living syntopically with *O. maranjabensis* are *Trapelus agilis agilis*, *Phrynocephalus maculatus maculatus*, *Eremias persica*, *Teratoscincus keyserlingii*, *Varanus griseus caspius*, and *Spalerosophis diadema shiraziana*.*

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*Note on syntopy vs sympatry: As used here, *syntopy* refers to species living in the same locality and habitat that may hypothetically constrain the fundamental niches of one another. *Sympatry* refers to species that share all or part of their distributional ranges. Sympatry, while it may reflect historical biogeography, has little ecological relevance except, perhaps, at the most general biome level (See Anderson 1999).

Discussion

The new species is closest morphologically to *Ophiomorus raithmai*, following the characters listed by Greer and Wilson (2001) and used in their cladistic analysis, and along with *O. raithmai* is separated from other members of the genus at their node 12. It is clearly distinct from that species in its much larger preocular, which blocks contact of the prefrontal with the supralabials, the parietals in contact behind the interparietal, and the nuchals in contact behind the parietals. This morphological resemblance is curious in light of the fact that *O. maranjabensis* is the westernmost species of the eastern clade, while *O. raithmai*, found in Sind Pakistan, and in western India, is the southeasternmost.

We were unable to obtain radiographs, and to compare skeletal characters with those examined by Greer and Wilson (2001) would require destructive dissection. This comparison must wait for a later study. We are not able to say what the similarities imply phylogenetically or biogeographically. One might speculate that the most evident head scale autapomorphies of the new species are derived character states.

The substrates into which the three-fingered species burrow are, at least superficially, similar. At this stage it is not fruitful to speculate as to how the various morphological specializations may be adaptively related to substrate differences. Detailed studies of the habitats of each of the species would be highly desirable.

For a detailed discussion of possible morphological evolution in the genus see Greer and Wilson (2001). There has not yet been a molecular study of the genus, and we hope that such a study may help to resolve aspects of the phylogeny, particularly about possible character reversals, and to establish at least a tentative timeline of speciation. *Ophiomorus tridactylus* is the most widely, but discontinuously distributed species; molecular studies may reveal distinct populations or cryptic species within this nominal taxon. To find most of the literature dealing with *Ophiomorus* see the bibliography of Southwest Asian herpetology by Leviton and Anderson (2010).

Figure 6. Habitat of *Ophiomorus maranjabensis*.

Figure 7. Tracks of *Ophiomorus maranjabensis* (courtesy of Gören Nilson).

Table 1. Counts and measurements for specimens examined.

Measurements	ZMGU2572 Holotype	ZMGU2571	ZMGU2570
Supralabials	6	6	6
Infralabials	6	6	6
Supraoculars	3	3	3
Postoculars	2	2	2
Preoculars	1	1	1
Loreal	1	1	1
Mental	1	1	1
Postmental	2	2	2
Parietal	1+1	1+1	1+1
Frontoparietal	0	0	0
Scales round the middle of the body	22	22	22
One third of anterior	22 or 23	21	22
One third of posterior	20	21	22
Scales between interparietal and level of vent	110	110	110
Preanals	2	2	2
Fingers	3	3	3
Toes	3	3	3
Snout-vent (mm)	75.25	69.6	84
Tail (mm)	43.7	51.4	64
Length of head, from end of snout to angle of jaw (mm)	6.6	5.9	7.2
Length of snout, from tip of snout to anterior corner of eye (mm)	4.15	3.6	4.3
Hind limb length (mm)	14.4	12.8	15
Forelimb length (mm)	5	4.6	5.4
Width of head (mm)	5	4.8	4.9
Height of head (mm)	4.4	4.4	4.7
Axilla - groin (mm)	56.5	51.9	65.5

Revised key to the genus *Ophiomorus*

Based on Anderson and Leviton (1966), Nilson and Andrén (1978), Anderson (1999).

1a. Limbs absent, scale rows less than 20 at midbody 2
1b. Limbs present, scale rows 20 or more at midbody 3

2a. Prefrontals small; frontonasal half or less than half as long as the frontal; scale rows 18 around posterior third of body .... *O. punctatissimus*
2b. No prefrontals; frontonasal much more than half as long as the frontal; scale rows 16 around posterior third of body .... *O. latastii*

3a. Fingers 4, toes 3 4
3b. Fingers 3, toes 2 or 3 7

4a. Scale rows 20 at midbody .... *O. blanfordi*
4b. Scale rows 22 or more at midbody 5

5a. Scale rows 22 6
5b. Scale rows 24 .... *O. chernovi*

6a. Nuchals equal to or about 1-1/2 times size of dorsal scales .... *O. brevipes*
6b. Nuchals about 2-1/2 times size of dorsals .... *O. nuchalis*

7a. Toes 2 .... *O. persicus*
7b. Toes 3 8

8a. Parietals in contact posteriorly; prefrontals not in contact with upper labials 9
8b. Parietals not in contact; prefrontals in contact with upper labials 10

9a. 20 scales at midbody .... *O. streeti*
9b. 22 scales at midbody .... *O. maranjabensis*

10a. Parietal in contact with anterior temporal; postocular scale about as large: as posterior suboculars; usually 7 or 8 scales on third (longest) toe .... *O. tridactylus*
10b. Parietal not in contact with anterior temporal (posterior temporal intervenes); postocular scale much larger than posterior suboculars; usually 4 scales on third (longest toe) .... *O. raithmai*

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Seyed Mahdi Kazemi earned his bachelor of science degree in animal biology from Qom Branch, Islamic Azad University, Iran, in 2007. He is currently working with Soheila Shafiei on *Phrynocephalus scutellatus* in Iran and writing a new book about snakes of Iran. Seyed also works on the taxonomy and biogeography of Iranian vipers. His research interests include other reptiles, especially snakes, taxonomy, ecology, and biogeography of the Iranian Plateau and the Middle East.

Steven C. Anderson has been involved with the herpetology and biogeography of Southwest Asia for more than 50 years. He first visited Iran, for nine months, in 1958 to collect material and make observations for his Ph.D. dissertation. At that time, his focus was on Khuzistan Province in southwestern Iran. Steve received his doctorate from Stanford University in 1966. Since that time, he has visited all of the principal geographical regions of Iran, as well as worked in Afghanistan and Turkey. Dr. Anderson has published well over 100 papers on the herpetofauna of Southwest Asia and three books. Many of these works were written with his co-author and collaborator, Dr. Alan E. Leviton of the California Academy of Sciences. From 1963 to 1970 Anderson worked as an associate curator at the California Academy of Sciences in San Francisco,

followed by 26 years as a professor at the University of the Pacific, while continuing as a research associate and fellow of the Academy. Since retirement in 1996, he has focused on promoting herpetology in Iran and encouraging and collaborating with students and faculty there. Dr. Anderson has also been a contributor and consulting editor (fauna) with *Encyclopaedia Iranica* since its inception.

SHORT COMMUNICATION

Notes on the natural history and distribution of *Carinatogecko stevenandersoni* Torki, 2011

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Abstract.—*Carinatogecko* Golubev and Szczerbak, 1981 comprises three species: *C. aspratilis* (Anderson 1973), distributed in Iran, *C. heteropholis* (Minton et al. 1970), distributed in a few areas in Iran and Iraq, and *C. stevenandersoni* Torki 2011, distributed in the western Iranian plateau (Minton et al. 1970; Anderson 1973, 1999; Golubev and Szczerbak 1981; Nazari-Serenjeh and Torki 2008; Torki 2011). *Carinatogecko stevenandersoni* was recently described by Torki (2011) and at that time known only from the type locality. In this study we report new localities and natural history for *C. stevenandersoni* in the western Iranian plateau. For natural history, we worked at the type locality and three other new localites during spring 2010 through early spring 2011.

Key words. *Carinatogecko stevenandersoni*, distribution, natural history, western Iranian Plateau

Distribution

Carinatogecko stevenandersoni was described from a single locality in the Tang-e-Gavshomar region (Ganj-Dare), Delphan City, Lorestan Province. During our recent fieldwork, we discovered three additional localities for *C. stevenandersoni* in the western Zagros Mountains, Lorestan Province, as follows: (1) Sepid-Koh mountain, Khorramabad, 33° 43´ N, 49° 54´ E; 1500-1700 m a.s.l.; this locality is covered by oak forest, syntopic reptiles as follows: snakes: *Rhynchocalamus melanocephalus*, *Platyceps rhodorachis*, *Hierophis* (s.l.) *andreanus*, *Typhlops vermicularis*, *Leptotyphlops macrorhynchus*, and *Macrovipera lebetina*; lizards: *Laudakia nupta*, *Ophisops elegans*, *Ablepharus pannonicus*, *Trachylepis aurata*, *Tropiocolotes helenae*, and *Asaccus griseonotus*. (2) Bababozorg, Nourabad-Kohdasht, 33° 55´ N 47° 45´ E; 1600-1900 m a.s.l., this locality covered by oak forest, syntopic reptiles as follows: snakes: *Rhynchocalamus melanocephalus*, *Platyceps najadum*, *Malpolon monspessulanus*, and *Macrovipera lebetina*; lizards: *Laudakia nupta*, *Trapelus lessonae*, *Acanthodactylus boskianus*, *Ophisops elegans*, *Ablepharus pannonicus*, *Trachylepis aurata*, and *Varanus griseus*. (3) Mehrab-Koh, Nourabad, 33° 54´ N 47° 45´ E; 1700-1800 m a.s.l., this locality covered by oak forest, syntopic reptiles as follows: snakes: *Rhynchocalamus melanocephalus*, *Dolichophis jugularis*, *Malpolon monspessulanus*, *Typhlops*

vermicularis, and *Macrovipera lebetina*; lizards: *Laudakia nupta*, *Trapelus lessonae*, *Lacerta media*, *Ophisops elegans*, *Ablepharus pannonicus*, *Trachylepis aurata*, and *Varanus griseus*.

All localities are covered by oak forest, as is true for the type locality (Torki 2011). Mountain structures in all localities is sedimentary.

In general, *C. stevenandersoni* is distributed in four localities, type locality, and three above localities. Based on mountain structures, *C. stevenandersoni* may be distributed in similar habitats in Kermanshah and Illam Provinces, as these same mountains continue into Illam and Kermanshah mountains.

Based on previous reports (e.g., Anderson 1999; Nazari-Serenjeh and Torki 2008; Torki 2011) *C. heteropholis* and *C. aspratilis* are distributed in low elevation (less than 1500 m). In contrast, *C. stevenandersoni* is distributed to above 1500 m a.s.l. Based on all available information about distribution of the genus *Carinatogecko*, *C. stevenandersoni* occurs at higher elevations than other species.

Natural History

Based on our fieldwork in all localities, *C. stevenandersoni* has seasonal activity as follows: activity started in late March to early September and in October, hiberna-

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tion began. This is the case for most reptiles in these regions (e.g., Torki 2009; Torki et al. 2010; Torki and Gharzi 2008). We did not observe any specimens during the cold season (late autumn to winter), because temperature at this time is very low. Therefore, hibernation occurred for *C. stevenandersoni* for less than six months.

Shelter sites of *C. stevenandersoni* are limited to between sedimentary stones. In the type locality, *C. stevenandersoni* has the same shelter sites with *Asaccus nasrullahi*, because the shelter site of *A. nasrullahi* is limited to cracks in sedimentary stones (Torki et al. 2010). Based on our field observations, *C. stevenandersoni* feeds on insects, larval insects, and spiders. In the type locality, *C. stevenandersoni* appears to share similar food items with *A. nasrullahi*, also a nocturnal gecko species. *Tropiocolotes helenae* is another gecko apparently in dietary competition with *C. stevenandersoni* in the type locality and Sepid-Koh. Nocturnal activity of *C. stevenandersoni* began at sunset and extended to before sunrise. In contrast, nocturnal activities of *A. nasrullahi* started shortly before sunrise and continued to morning, and in some rare specimens, to midday. Important predators of *C. stevenandersoni* are *Rhynchocalamus melanocephalus* and *Hierophis* (s.l.) *andreanus*. Under captive conditions, *Ophisops elegans* and *Trachylepis aurata* eat *C. stevenandersoni*. Some large scorpions easily killed and ate *C. stevenandersoni* (especially juvenile specimens). This also occurred for other small geckos, such as *Tropiocolotes helenae* (e.g., Torki and Gharzi 2008).

Based on field observations, we see two eggs in most female specimens, and a few specimens have one egg in the abdomen. We transferred two female specimens to lab conditions; both specimens had eggs in their abdomen. Eggs in *C. stevenandersoni* are spherical, white. Egg laying in *C. stevenandersoni* occurred on the surface of stones, in crack(s) of rocky stones. Egg laying in both female specimens occurred in June. Hatching occurred 38-45 days after eggs were laid. Coloration of juvenile specimens (lighter) is different from adult specimens (mostly darker). This is similar to the genus *Asaccus* and in contrast to *Hemidactylus flaviviridis* (Iranian populations; our observations, unpubl. data). The tail of juvenile specimens of *C. stevenandersoni* is yellowish (different from body); this is in contrast to adult specimens.

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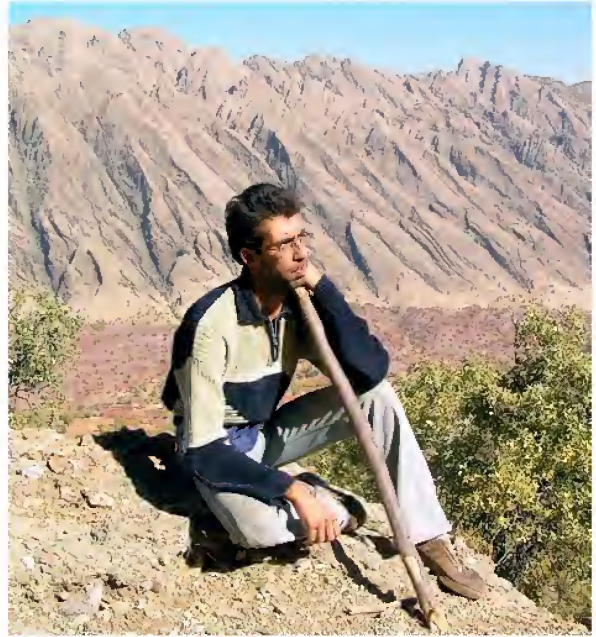
Reza Sadeghi earned his B.Sc. in Animal Biology from Tehran University and M.Sc. in Animal Biosystematics from Tehran University. He is currently a member of the faculty in the Department of Biology, Islamic Azad University of Boroujerd, Lorestan, Iran. In addition he studies geometric morphometrics, morphology, systematics, and taxonomy of the Iranian Plateau fauna with special interest in insects and reptiles. His M.Sc. thesis was a geometric morphometric study on host plants associated with variations of the codling moth (*Cydia pomonella*) populations in parts of Iran.

Farhang Torki earned his Bachelor of Science (B.Sc.) degree in animal biology from Lorestan University and his Masters of Science (M.Sc.) degree in animal biosystematics from Razi University. During his B.Sc. studies, he worked on histological and embryological methods, especially on spermatogenesis and oogenesis of reptiles, and the herpetofauna of Lorestan Province. During his graduate studies (M.Sc.) he worked on the systematics of amphibians and reptiles of the southern and western Iranian Plateau and continued developmental biology work in herpetology. Following his graduate work he established the Farhang Torki Ecology and Herpetology Center for Research (FTEHCR) and the Farhand Torki Herpetology Museum (FTHM). The purpose of his center during 2007-2010 was based on ecology and systematics of Iranian herpetology. The FTEHCR is an independent institution supported solely by a bequest from his father. Currently, Farhang is studying the ecology and evolution of geckos in Iran, especially the behavioral evolution of *Asaccus* and *Tropiocolotes*.

A brief history and current status of herpetology in Iran

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Abstract.—In this paper, we present a brief history of herpetology in Iran, discuss its current status,
and review some important works carried out by Iranian and non-Iranian herpetologists. Current
problems, information, and challenges associated with herpetology in Iran are presented. Finally,
current herpetological studies in Iran are introduced and potential biodiversity hotspots of herpe-
tofauna in Iran are identified. These potential hotspots are strongly recommended by experts in the
country to be considered for studies at the graduate level.

Key words. History, Iran, herpetology, status, studies, biodiversity hotspots, education

The herpetofauna of Iran is rich and diverse. In terms of species richness and taxonomic diversity of reptiles, this area harbors one of the most remarkable reptile faunas within the western Palearctic region, owing to both high habitat diversity and historical biogeographical factors.

Most amphibians and reptiles of Iran were originally described by non-Iranian herpetologists in the "classical" literature of scientific natural history, but recently, herpe-tological studies by Iranian herpetologists have expanded rapidly.

Unfortunately, despite the high diversity of the Ira-nian Plateau herpetofaouna, the number of research stud-ies carried out in this field has been limited. For the last century, only a few reliable books have been published by Iranian herpetologists: *Amphibians of Iran* (Balouch and Kami 1995), *Snakes of Iran* (Latifi 1991, 2000), and *Field Guide to the Lizards of Iran* (Rastegar-Pouyani et al. 2006, 2007) are the main herpetological texts (in Farsi and/or Persian) in Iran.

New molecular data and computational phylogenetic methods are transforming the field of herpetology in a number of ways, and many of these same transforma-tions have occurred in other groups of organisms. These approaches are overturning or questioning many tra-ditional ideas about reptile and amphibian phylogeny based on morphology. In recent years, Iranian herpetolo-gists have been using these advanced methods to reveal the species relationships of amphibians and reptiles of Iran. Given current trends, we hope that the phylogeny of most reptile and amphibian groups will be resolved in the following years, at least at the level of currently recognized genera.

Recognizing the conservation status of endemic spe-cies of amphibians and reptiles is of great importance. The Iranian herpetofauna consists of about 15 species of Anura (frogs and toads), seven species of Caudata (sala-manders), nine species and six subspecies of Testudines (Chelonia; turtles, terrapins, and tortoises), one species of Crocodilian, one species of amphisbaenian, more than 135 species of Lacertilia (lizards), and about 85 species of Serpentes (snakes). Of this great herpetofaunal diver-sity, conservation status has been clearly delineated for only two species of newts (*Neurergus microspilotus* and *N. kaiseri*) from western Iran. Owing to causes including lack of public knowledge about the significance of wild-life, habitat destruction, overuse of natural resources, road expansions, lack of public environmental knowl-edge and education, legal and illegal use of firearms, and environmental pollution, Iranian herpetofaunal biodiver-sity is under serious threat.

Thus, it is necessary for Iranian herpetologists to take special and effective steps in the study of the indigenous herpetofaunal species of Iran to determine their conser-vation status. The Iranian Plateau herpetofauna has suf-fered from numerous devastating factors: the high rate of human population growth in Iran, coupled with the rela-tively low standard of living, create social conditions that act to erode the remaining expanses of undisturbed veg-etation, including those located within protected areas. Deforestation rates in Iran are very high, and the amount of forest in Iran is expected to decrease to a little more than a third of its original total.

With regard to the limited distribution of endemic spe-cies of the Iranian herpetofauna, determining the conser-

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Figure 1. The spider viper *Pseudocerastes urarachnoides* in natural habitat, western Iran. Photo by Behzad Fathinia.

Figure 2. The Kermanshah cave gecko, *Asaccus kermanshahensis*, in natural habitat. Photo by Nasrullah Rastegar-Pouyani.

Figure 3. The Loristan newt, *Neurergus kaiseri*. Photo by Bill Love; http://www.bluechameleon.org.

vation status of wide-ranging species like *Macrovipera lebetina*, *Pseudocerastes persicus*, and *Trapelus agilis* is easier than narrowly endemic taxa, such as *P. urarachnoides* (Fig. 1), *Bufo luristanica*, *B. kavirensis*, *Montivipera latifi*, *Asaccus kermanshahensis* (Fig. 2), *A. nasrullahi*, *A. kurdestanensis*, and *Tropiocolotes latifi*.

A recent effort toward understanding the conservation status of amphibians and reptiles in Iran was an IUCN-SSC workshop in Antalya, Turkey to establish Red Book status for all species of the Caucasus, Turkey, and Iran. This workshop was attended by Iranian researchers, as well as representatives from America and Europe involved with the fauna of this region. Although this was only a preliminary step, the workshop was useful in producing tentative distribution maps for all species and identifying areas of research needed to answer conservation problems. One definitive outcome was the development of sufficient information leading to a CITES listing for the narrowly endemic endangered salamander, *Neurergus kaiseri* (Fig. 3).

Based on long term surveys by researchers in different habitats and areas across Iran, regions with high numbers of taxonomically problematic groups have been identified. These problematic taxa need special attention by researchers and young scientists of the country. Some interesting reports include the rumored presence of *Mesalina guttulata* in the plains of Khuzestan, southwestern Iran, the possible presence of *Phrynocephalus raddei raddei* in Kopet Dagh valleys on the border of Iran and Turkmenistan, the presence of *Cyrtopodion kotschyi* in northwestern Iran, and a high degree of individual variation in morphology in *Tropiocolotes persicus* ssp. south-

west of Minab in southern Iran. Further, the taxonomic status of the relict genus Asaccus using molecular and morphological approaches should be addressed within the framework of a Ph.D. thesis. Also, the genus *Ophiomorus* needs further studies and investigations employing morphological and molecular tools.

While there is an ongoing need to further ascertain the range and distribution of all species, there are a number of geographic areas where additional exploration and detailed collecting are particularly needed. The western Zagros Mountains in Iran, Iraq, and southeastern Turkey have been shown to be areas of high endemism and diversity, where new taxa are being described. The authors consider that more herpetological surveys will produce even more species. The Jaz Murian Depression in southeastern Iran, west of Iranshahr, although little-explored, has yielded three narrowly distributed endemic species, *Mediodactylus sagittifer*, *Ophiomorus streeti*, and an undescribed species of *Scincus* (Anderson 1999a). Few of the many internal mountain ranges of the Central Plateau of Iran have been explored zoologically. Some of these may prove to be ecological islands of population divergence. The Dasht-e Lut has been virtually impenetrable in the past, but the advent of improved field transportation now enables faunal surveys. This region is not expected to have great diversity or population densities, owing to its extremely arid and severe conditions, but studies will reveal interesting adaptations that provide for the survival of fauna in these harsh environments. The Makran Range forms the border of the southeastern edge of the Iranian Plateau and has yet to be adequately surveyed for fauna in Iran, Afghanistan, or Pakistan,

where tribal unrest and military intervention has made the possibility of surveys problematic in the two last countries. Over the last half century, a number of species (such as *Lytorhynchus maynardi*, *Eristicophis macmahonii*, and *Rhinogecko misonnei*) previously known from Pakistani Balochistan have been found in eastern Baluchistan, indicating that the ranges of more Pakistani and Afghani fauna may extend west into Iranian Baluchistan. The collections of the Afghan Boundary Commission more than a century ago produced many species endemic to that region, and only sporadic collection has occurred along this border since. Kuh-e Taftan, also rarely visited, yielded the lizard species *Eremias lalezharica*, described less than 20 years ago; it has not been visited by herpetologists since. Only random collecting has been done on the islands of the Persian Gulf, apart from Qeshm Island. Recent information suggests that the fauna of these islands have much to reveal about trans-gulf connections.

In order to better promote herpetology in Iran, a national herpetological society that publishes, at least annually, developments in Iranian herpetology is desirable. A network to facilitate exchange of ideas and published literature and a repository of electronic copies of past and present world literature pertaining to the taxa of amphibians and reptiles of Iran would be helpful. At least two existing websites, Pars Herpetologists Institution (http://www.pars-herp.org/) founded by Omid Mozaffari, and Steven Anderson's personal website (http://swasiazoology.tripod), were begun with the intention of serving some of these needs. Both are still in development, but they require more time and effort than has proven possible thus far.

It may be worth noting that the attendance of Iranian herpetologists at national and international meetings has increased as research and publication have progressed. The first herpetological meeting in Iran was held at Kerman in February 2009 and several faculty and students attended the SEH meeting in Turkey in 2009.

At present, there is a lack of local suppliers of the books and equipment necessary for professional herpetologists and herpetoculturalists to maintain animals in captivity.

There is also a developing interest by private or amateur herpetologists towards herpetology in Iran. Although not funded by the taxpayers, in recent years these individuals have made major contributions toward supplementing the studies of academic herpetologists.

Iran has a rather long history of herpetological studies, from the 1700s until the present. The original scientific herpetological studies were mostly carried out by non-Iranian researchers (e.g., Olivier, Blanford, Zarudny, De Filippi, and Nesterov) but modern studies have been carried out mainly by young native herpetologists. Here we present a brief history of contemporary herpetologists who have made important contributions in the study of the Iranian Plateau herpetofauna.

Taxonomic and faunistic studies on the herpetofauna of Iran were carried out by Steven C. Anderson (e.g., 1963, 1966a,b,c, 1974, 1999a, b; Fig. 4) who spent about nine months in Iran during 1958 and paid a shorter visit to the country in 1975. In 1999, Anderson published the results of his 40-year studies in a book entitled *The Lizards of Iran* (Anderson 1999a). Currently, this book is considered a key reference for all herpetologists in Iran, both experts and amateurs, in spite of the fact that the taxonomy of many taxa has been superseded as a result of subsequent studies. Of the other contemporary herpetologists, we mention Göran Nilson and Claes Andrén (Fig. 5), the Swedish herpetologists who visited Iran a number of times (1973, 1976, 2000, 2002) and made important contributions in the study of the Iranian Plateau Amphibians and Reptiles, describing *Bufo kavirensis* and *Ophiomorus nuchalis*, among others.

The late Mahmoud Latifi (Fig. 6), a researcher of the Razi Institute considered one of the pioneers in serum production in the world, published a book entitled *The Snakes of Iran* in 1984 (see also Latifi 1991, 2000), with illustrations and an identification key for all recognized species. As with Anderson's book, many of the generic names of these snakes have since changed.

Mohammed Baloutch, during a series of herpetological expeditions in Iran, trained a generation of herpetologists and described two new species of lizards (Baloutch 1976, 1986). Together with Haji Gholi Kami (another contemporary herpetologist), Baloutch published the only textbook on Iranian amphibians entitled *Amphibians of Iran* (Baloutch and Kami 1995) (in Persian). The history of herpetological studies in Iran prior to the current century has been presented by Anderson (1999a, b).

Since 1988, ongoing studies by N. Rastegar-Pouyani and his younger brother E. Rastegar-Pouyani (Fig. 7) have led to descriptions of numerous new taxa of reptiles (e.g., N. Rastegar-Pouyani 1996, 1997, 1998, 1999; Rastegar-Pouyani and Nilson 1997, 1998; Rastegar-Pouyani and Rastegar-Pouyani 2001; Rastegar-Pouyani, Nilson, and Faizi 2006) and are among the most comprehensive studies in Iranian herpetology. Fortunately, today there are some young and active herpetologists (co-authors of this paper among them) devoting their studies to the Iranian Plateau herpetofauna and conducting field research in various parts of the country.

Various universities and institutions in Iran are offering programs in order to enhance the knowledge of herpetology among Iranian students, both undergraduate and graduate. These include Shahid Bahonar University and International Center for Science, High Technology and Environmental Science Zoological Museum (ICSTZM) in Kerman Province, which is directed by Soheila Shafiei (a Ph.D. student in herpetology) and Mehdi Rajabizadeh (M.Sc. in herpetology) respectively. Gorgan University, directed by Haji Gholi Kami, also offers a major collection of the amphibians and reptiles of Iran in

Figure 4. Steven C. Anderson (left) and Nasrullah Rastegar-Pouyani (right) at the 3rd World Congress of Herpetology, Prague, Czech Republic, August 1997. Photo by Natalia Ananjeva.

Figure 5. Claes Andrén (left), N. Rastegar-Pouyani (middle) and Göran Nilson (right) at the 3rd Asian Herpetological Meeting, Almaty, Kazakhstan, September 1998. Photo by Sahat Shamakov.

Figure 6. The late Mahmoud Latifi. Unknown photographer.

Figure 7. Type locality of *Eremias montanus*, 19 June 2004 (the senior author, left, and Eskandar Rastegar-Pouyani, right). Photo by Maysam Rastegar-Pouyani.

its zoological museum, providing a very good resource for herpetological studies. This museum collection is known as the Gorgan University Zoological Museum (GUZM). In collaboration, the Razi University Zoological Museum (RUZM) also provides a valuable collection of amphibians and reptiles belonging to most families and genera that have been collected over Iran. This collection is directed and managed by the senior author. Further, graduate programs in herpetology are also offered by Department of Biology, Razi University, which has produced various peer-reviewed herpetological papers, M.Sc, theses, and Ph.D. dissertations. At Razi University, the masters program in herpetology was established by the senior author in 2000 and a new Ph.D. program in herpetology in 2010, the students of which are trained in various aspects of herpetology in the Iranian Plateau, mainly focusing on problematic taxa of amphibians and reptiles. These broad studies employ morphological, molecular, and ecological approaches. The main authority in molecular herpetology in Iran is one of us (E. Rastegar-Pouyani) from the Teacher-Training University of Sabzevar, Khorasan Province, who graduated from Heidelberg University in Germany after studying the molecular phylogenetics of reptiles, with the *Eremias persica* complex as the main subject of his doctoral dissertation.

There are also conservation programs and projects offered by the Department of the Environment (DOE) that try to expand and increase the knowledge of herpetology in Iran. These programs and projects are mainly conducted and carried out by a variety of the above-mentioned herpetologists, as well as by the co-authors of this paper. The MMTT (Iranian National Natural History Museum), which once was a center of research with a very nice exhibition in Tehran, is now incorporated into the general collections and exhibitions of the Department of the Environment. Some workers (e.g., N. Rastegar-Pouyani, and S. C. Anderson) have been interacting with the MMTT at various periods, and the senior author and Haji Gholi Kami from Gorgan University worked as herpetologists in the MMTT from 1989 to 1992.

An updated checklist of the reptiles and amphibians of Iran (Rastegar-Pouyani et al. 2008) enumerated the number of amphibians, lizards, snakes, and turtles of the country. This paper was published in the recently established Iranian Journal of Animal Biosystematics (IJAB).

In summary, Iran has a long-lasting history in herpetological studies and, as a complicated and rich region from the herpetological point of view, warrants more comprehensive studies on its herpetofauna using various disciplines. In this way, it is hoped that more new taxa and new discoveries will be uncovered and that more herpetologists will become devoted and active in the study of Iranian amphibians and reptiles thus helping protect these wonderful animals for future generations.

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Sexual dimorphism in *Carinatogecko heteropholis* (Minton, Anderson, and Anderson, 1970) (Sauria: Gekkonidae) from Ilam Province, western Iran

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Abstract.—Sexual dimorphism is a widespread phenomenon in animals, but so far undocumented in *Carinatogecko heteropholis*. In this study, 52 specimens were collected in Karezan, Ilam province, western Iran. The uni- and multivariate analyses performed on the morphological data revealed that females are larger than males. All of the sexual differences were female-biased, except for the infralabial scales.

Key words. *Carinatogecko heteropholis*, sexual dimorphism, statistical analysis, morphology, Ilam Province, Iran

Introduction

The genus *Carinatogecko* Golubev and Szczerbak, 1981 comprises three species, the Iranian keel-scaled gecko, the Iraqi keel-scaled gecko, and Anderson's keel-scaled gecko: all of them are found on the Iranian Plateau (Szczerbak and Golubev 1996; Anderson 1999; Torki 2011). The Iraqi keel-scaled gecko, *Carinatogecko heteropholis* (Minton, Anderson, and Anderson 1970) is a small species; its type locality in Iran is western Zagros foothills (Anderson 1999; Fathinia 2007; Rastegar-Pouyani et al. 2007). It is hypothesized that the genus *Carinatogecko* has a double Iranian-Mesopotamian origin (Fathinia 2007).

Sexual dimorphism (SD) is a common and widespread phenomenon in the animal world (Andersson 1994). Sexual size dimorphism (SSD) explains the status in which the males and females differ in measured values of certain morphological characteristics. Sexual size dimorphism (SSD) has been extensively described in reptiles (Andersson 1994; Kuo 2009). Sexual dimorphism in animals is revealed in three different aspects: behavior, size, and shape (Selander 1972). Numerous surveys have been carried out on sexual dimorphism in lizards (Stamps 1983; Rocha 1996; Carothers 1984; Trivers 1976; Molina-Borja 2003; Baird et al. 2003; Verrastro 2004; Bruner et al. 2005; Kaliontzopoulou et al. 2007).

Differences in the selective forces acting on male versus female body size are the main causes of sex differences in adult body size of animals (Cox 2006). Sexual dimorphism in lizards may result from differences in

food resource partitioning and sexual differences in energy allocation to growth (Baird et al. 2003).

To our knowledge this is the first survey on the occurrence of sexual dimorphism in the genus *Carinatogecko*. Clarifying the sexually distinctive traits in *C. heteropholis* is of evolutionary and systematic importance; in this paper, we report results of such a study.

Material and methods

A total of 52 (28♂ and 24♀) adult specimens were collected during summer 2010. All of them were collected by hand with the aid of an electric torch at night on rocky mountain sides of the Zagros Mountains in Karezan, Shirvan-Chardavol, Ilam Province, western Iran (Fig. 1). Of these, 22 specimens were fixed in ethanol 75% and deposited in the RUZM (Razi University Zoological Museum) for future studies, and the rest (30 specimens) were released in their relevant habitat 24 hours after collecting and analyzing. The coordinates of the study site are 33°44′ N, 46°29′ E1325 m a.s.l. Eight metric and four meristic variables were chosen and measured by digital caliper and stereomicroscope to the nearest 0.01 mm (Table 1). Except for overall shape differences which can be used to distinguish males from females (Fig. 2), sex of specimens was mainly determined based on presence of two swellings at the base of tail just behind vent in males and their absence in females (Fig. 3).

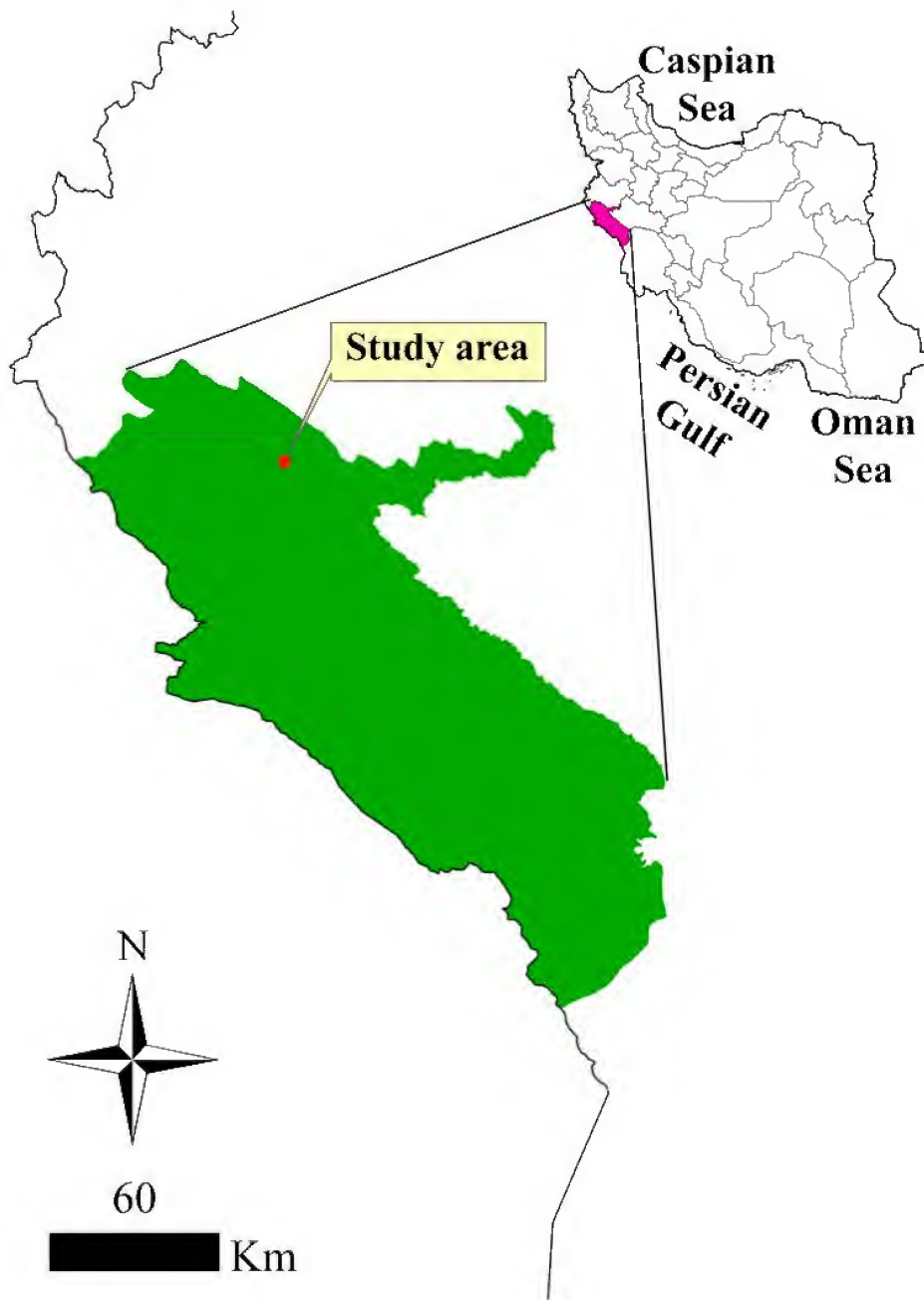**Correspondence.** [3]*Email: bfathinia@gmail.com*

Figure 1. Map showing the coordinates of the study site in Karezan region at mountainsides of the Zagros.

To determine the significance of sexual dimorphism in *C. heteropholis*, the ANOVA Table as well as Principal Component Analysis (PCA: correlation matrix) were used. The SPSS statistical software (version 13) was used for carrying out the statistical analyses.

Results

Twelve morphological characters (eight metric and four meristic) were included in the analysis. The values for

the metric and meristic characters as well as the direction of differences and the significant characters ($P < 0.05$) are summarized in Table 2.

ANOVA Table Analysis

Metric variables: obvious differences in the value of variables are observed between the sexes. Females have significantly greater values than the males for eight metric characters. In the case of body length and the distance

Figure 2. Dorsal view of male (left) and female (right) of *Carinatogecko heteropholis*.

Figure 3. Presence of swelling in the male of *C. heteropholis* at base of the tail which accommodate hemipenes (left) and their absence in female (right).
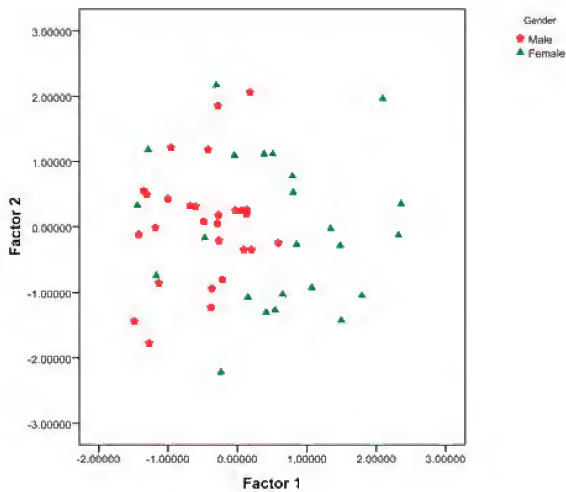
Figure 4. Ordination of the individual males and females of *Carinatogecko heteropholis* on the first two principal components. Note the relative degree of isolation between males and females, which is mainly attributed to SVL, TL, HL, HW, LFL, LHL, FHL, and VL in the PC1 and SL and IL in the PC2.

between forelimb – hindlimb (i.e., SVL and FHL, respectively) females had values of 36.34 ± 0.63 and 18.02 ± 0.41 and males had 32.53 ± 0.33 and 15.41 ± 0.20 (P < 0.05). Regarding the differences in extremities (forelimb, hindlimb, and tail) between females and males we observed that females had values of 12.96 ± 0.22, 17.46 ± 0.30, and 39.11 ± 0.80 and males had values of 11.86 ± 0.10, 15.95 ± 0.19, and 36.74 ± 0.68 for LFL, LHL, and TL respectively. Head dimensions also show significant differences between the sexes. Females had values of 8.94 ± 0.13 and 6.99 ± 0.10 and males had 8.51 ± 0.08 and 6.65 ± 0.07 for HL (head length) and HW (head width), respectively. Regarding the last metric character (i.e., VL or vent length), we realized that this character is significantly different between females and males, so that females have significantly greater values for VL (3.58 ±

Table 1. The metric and meristic characters used in this study.

	Characters	Definition
Metric	SVL	snout to vent length
	TL	length of tail
	HL	head length
	HW	head width
	LFL	length of forelimb
	LHL	length of hindlimb
	FHL	forelimb to hindlimb length
	VL	the greatest horizontal length of vent
Meristic	SL	number of supralabial scales
	IL	number of infralabial scales
	CT	number of crossbars on the tail
	CD	number of chevrons on dorsum

0.10) than males (3.34 ± 0.04) (P < 0.05). All the metric variables are female biased. Reasons for presence of female biased sexual size dimorphism in the species are taken up in the discussion section.

Meristic variables: Significant differences were not observed in meristic variables, but SL (8.20 ± 0.12), CT (12.16 ± 0.24), and CD (7.45 ± 0.17) in females are larger than SL (8.07 ± 0.10), CT (11.96 ± 0.21), and CD (7.32 ± 0.14) in males. In other words, the three characters are not significantly female biased. Only one out of twelve variables (i.e., number of infralabials, IL) was male biased, which in turn was insignificant. The value of IL in males (6.85 ± 0.09) was insignificantly greater than that in females (6.79 ± 0.13) (P < 0.05).

Principal Component Analysis

The PCA performed on the dataset yielded three axes, which collectively explained 73.38% of the total variation. The PC1 explains 50.788% of the total variation. Inspection of the loadings indicates that correlations with all morphological measurements have the same sign (positive) but not the same magnitude (Table 3). The first axis is a clear indicator of body size. All metric variables in the first axis have greater values than meristic ones, hence making a greater contribution in sexual discrimination. The scores of the females along this axis show an overlap with those for males, indicating that although sexual dimorphism occurs between males and females, the two sexes are not completely separated from each other regarding these characters (Fig. 4). The second axis, which contains 12.51% of the total variation is a meristic axis that records individuals at one end with large SL and IL and relatively small SVL compared with individuals with small SL and IL and relatively large SVL. The third axis contains only 10.08% of the total variation, being a meristic axis that records individuals with large CT and CD and relatively small VL at one end, compared with individuals at the other end with small CT and CD and relatively high values for VL.

Discussion

Carinatogecko heteropholis presented marked sexual dimorphism in general body size and several body parts, with females being significantly larger than males in eight out of 12 studied characters.

The evolutionary result of selection acting differently on body size and the rest of male and female traits is sexual size dimorphism (SSD) (Andersson 1994). Both the proximate (growth patterns) and ultimate (evolutionary payoffs) causes are responsible for sexual dimorphism (Stamps 1993; Cox et al. 2003; Kuo et al. 2009). Regarding size dimorphism, the proximate cause is an agent which creates intersexual differences in growth rate. Among these proximate causes, two are mention-

Table 2. Comparison of 12 morphological characters in males and females of *Carinatogecko heteropholis*. SE: standard error, D of d: Direction of difference. All measurements in millimeter (mm). Abbreviations: SVL (snout-vent length), TL (length of tail), HL (head length), HW (head width), LFL (length of forelimb), LHL (length of hindlimb), FHL (forelimb-hindlimb length), VL (the greatest horizontal length of vent), SL (number of supralabial scales), IL (number of infralabial scales), CT (number of crossbars on the tail), and CD (number of chevrons on dorsum).

SEX		SVL	TL	HL	HW	LFL	LHL	FHL	VL	SL	IL	CT	CD
♂	Mean	32.53	36.74	8.51	6.65	11.86	15.95	15.41	3.34	8.07	6.85	11.96	7.32
	N	28	21	28	28	28	28	28	28	28	28	28	28
	SEM	0.33	0.68	0.08	0.07	0.10	0.19	0.20	0.04	0.10	0.09	0.21	0.14
♀	Mean	36.34	39.11	8.94	6.99	12.96	17.46	18.02	3.58	8.20	6.79	12.16	7.45
	N	24	24	24	24	24	24	24	24	24	24	24	24
	SEM	0.63	0.80	0.13	0.10	0.22	0.30	0.41	0.10	0.12	0.13	0.24	0.17
	D. of d.	F>M	F>M	F>M	F>M	F>M	F>M	F>M	F>M	F>M	M>F	F>M	F>M
	P-value	0.000	0.027	0.008	0.009	0.000	0.000	0.000	0.030	0.386	0.691	0.530	0.542

able: differences in growth hormone concentrations and trade-offs in allocating energy between growth and reproduction (John-Adler et al. 2007; Kuo et al. 2009). Presence of dimorphism between males and females are defined by three main forces including: sexual, fecundity, and natural selection (Olsson et al. 2002; Cox et al. 2003; Kaliontzopoulou et al. 2007).

Ectotherms grow continuously throughout life and they show a tendency to produce abundant, varying numbers of progeny, which results in a vigorous correlation between fecundity and body size of females, and

Table 3. Loadings from a Principal Component Analysis of metric and meristic characters of *Carinatogecko heteropholis*. Variables loading strongly on each principal component are in bold. Abbreviations: SVL (snout-vent length), TL (length of tail), HL (head length), HW (head width), LFL (length of forelimb), LHL (length of hindlimb), FHL (forelimb-hindlimb length), VL (the greatest horizontal length of vent), SL (number of supralabial scales), IL (number of infralabial scales), CT (number of crossbars on the tail), and CD (number of chevrons on dorsum).

Variable	PC1	PC2	PC3
SVL	**0.958**	-0.133	-0.054
TL	**0.791**	0.061	0.003
HL	**0.884**	-0.057	-0.042
HW	**0.848**	-0.087	-0.032
LFL	**0.907**	-0.055	-0.031
LHL	**0.911**	-0.073	-0.028
FHL	**0.833**	-0.066	-0.007
VL	**0.756**	0.254	**-0.195**
SL	0.147	**0.784**	-0.064
IL	0.102	**0.851**	0.077
CT	0.286	-0.156	**0.748**
CD	0.140	0.174	**0.771**
Eigenvalue	6.095	1.502	1.210
% Variance	50.788	12.513	10.085
Cumulative	50.788	63.301	73.386

probably that is why SSD in ectotherms is predominantly female-biased (Trivers 1972). The SVL (snout-vent length) and FHL (forelimb to hindlimb length) in females of *C. heteropholis* are greater than those in males. In other words, the two characters, SVL and FHL, are female-biased which can be the result of fecundity selection in the species. A larger abdominal volume is an ultimate cause which is selected in females because this feature enhances fecundity (Monnet and Cherry 2002, Tague 2005; Kuo et al. 2009).

Head size in a variety of lizards is male-biased (e.g. Verrastro 2004; Smith and Nickel 2002; Vial and Stewart 1989; Anderson and Vitt 1990; Castilla and Bauwens 1991; Mouton and van Wyk 1993; Vitt and Colli 1994; Barbadillo et al. 1995; Hews 1996; Smith et al. 1997; Shine et al. 1998; Kratochvíl and Frynta 2002). In the cases of HL (head length) and HW (head width) in *C. heteropholis*, females have significantly greater values than males. As reported for other vertebrates, a phenomenon which can support niche divergence hypothesis is dimorphism in head size (Selander 1972; Shine 1989). Reproductive role hypothesis is a hypothesis that explains differences in head size. Females have a greater contribution in reproduction (Darwin 1871) and a larger head should maximize energy intake. This idea may explain the presence of larger heads in females of *C. heteropholis*.

Further, in *C. heteropholis*, the volumes of LFL (length of forelimb) and LHL (length of hindlimb) in females are significantly greater than in males. Sexually size-adapted dimorphism in traits such as head, limb, and tail measurements are assigned to an artifact of the acceptance of SVL for scaling to body size (Kratochvíl et. al. 2003). Moreover, we suggest that longer and stronger limbs are necessary to support greater distance between forelimb and hindlimb (i.e., greater FHL) either in females or in males.

Our results show that in the case of *C. heteropholis* the VL (vent length) in females is significantly greater than in males. During mating, females with a larger VL

are chosen by males. According to Andersson (1994), this character in geckos may be the result of selection for fecundity as well as selection for a larger female VL during evolution.

Additional studies are needed to determine which of these alternatives best explain the occurrence of sexual dimorphism in *C. heteropholis*.

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Additional information on Misonne's swollen-nose gecko, *Rhinogecko misonnei* de Witte, 1973 (Squamata, Geckonidae) in Iran

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Abstract.—Three adult specimens of Misonne's swollen-nose gecko (*Rhinogecko misonnei*) were collected in the west of Dasht-e-Lut desert in eastern Iran during fieldwork conducted April to August 2009. The new locality of the species is situated about 100 km west of the type locality. Information on habitat, pholidosis, and coloration is given. This record indicates a wider distribution of *Rhinogecko misonnei* in southeastern Iran.

Key words. Misonne's swollen-nose gecko, *Rhinogecko misonnei*, Iran, distribution, new locality

Introduction

Misonne's swollen-nose gecko (*Rhinogecko misonnei*) was first described from "Dasht-e-Lut" (30°13′N, 58°47′E) by de Witte (1973). The holotype (IRSNB 2514) is kept in the L 'Institute Royal des Sciences Nnaturelles de Belgiques (Brussels). Szczerbak and Golubev (1996) placed this species in the genus *Agamura*, whereas, according to Anderson (1999), *Rhinogecko* is a distinct genus. No other specimens have been available until during fieldwork in Kerman Province from 30 April to 13 August 2009, three specimens of *Rhinogecko misonnei* were collected. As there are no data on the distribution and description of this species beyond that of the type description, this information and some ecological data are presented here.

Methods and materials

Three specimens were collected from three localities as follows: ZMSBUK 700 (♂): 30°34'40.18"N, 57°51'9.03"E, 306 m elevation. ZMSBUK 701 (♀): 30°33'5.30"N, 57°51'50.24"E, 300 m elevation. ZMSBUK 702 (♀): 30°29'42.03"N, 57°44'12.01"E, 368 m elevation. This area is situated in the west of Lut block (National Geosciences Database of Iran 2010) in southeastern Iran. Specimens were deposited in the Zoological Museum Shahid Bahonar University of Kerman (ZMSBUK).

We examined a set of six morphometric, and eight meristic characters and compared these characters with the holotype. The following characters were used for morphological analysis, (abbreviations and measurement details are given in parentheses): snout-vent length (SVL; from tip of the snout to cloaca), tail length (TaL; from cloaca to tip of the tail), head height (HH; behind eyes), head width (HW; behind eyes), orbit diameter (OrD; from anterior to posterior margin of orbit), ear length (EaL; at widest point of the ear opening). All measurements were taken with calipers to the nearest 0.1 mm.

For better comparison of the specimens, several ratios were calculated. These are head ratio (HHW; head height to width ratio × 100), ear ratio (EED; ear opening to eye diameter ratio ×100), and body length ratio (SVL/TL).

Meristic characters: number of transverse ventral scales (TVe; across midbody), number of longitudinal ventral scales (LVe; between mental and cloaca), number of active precloacal pores (PPo; in male only), number of supralabials (SLa), number of infralabials (ILa), number of enlarged scales on lower surface of thigh (LsT), number of scales across the head (SaH; interorbital, the scales on the ridge above the eyes were not counted), and number of scales around dorsal tubercles (SdT).

Results

Nasal shields of these specimens distinctly swollen and erect, forming a short tube-like structure (Fig. 4, A); the nasal caruncle formed by three nasal scales (Fig. 4, D);

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Table 1. Measurements for *Rhinogecko misonnei*. Character abbreviations as explained in the text. Asterisk indicates holotype and paratype (Szczerbak and Golubev 1996).

	IRSNB 2514, BZ 24.703 Reg. 25/6*	ZMSBUK 700	ZMSBUK 701	ZMSBUK 702
Sex		male	female	female
SLa	9-12	12-13	12-12	9-10
ILa	8-11	9-10	9-9	9-10
TVe	26-28	22	22	26
LVe	120	123	120	127
SdT	8-9	9-10	9-10	9-10
SaH	16	17	15	19
LsT	9-12	12	12	11
PPo	4-8	6	-	-
SVL	56.9-61.0mm	56 mm	60 mm	56 mm
TaL	58.0-73.0mm	-	75 mm	-
HH	-	6.6 mm	7.7 mm	5.5 mm
HW	-	9.7 mm	11 mm	9.2 mm
OrD	-	4.6mm	4.1mm	4.0mm
EaL	-	2.0mm	2.0mm	2.0mm
SVL/TL	0.84-0.96	-	0.80	-
HHW	56	68	71	60
EED	53	43	48	50

22-26 scales across abdomen; a row of 11-12 enlarged scales on lower surface of thigh (Fig. 4, G); Tail slightly longer than body. Complete measurements of all specimens are presented in Table 1.

Color pattern

Dorsum gray, light brown to gray-brown, with five broad dark brown crossbars, seven on tail, limbs with broad brown bars less dark than those of body and tail, anterior labial scales with dark brown spots, venter whitish (Fig. 3).

Distribution and habitat

This species is known from the remote Dasht-e Lut desert in southeastern Iran (Fig. 2) and reported from Pakistan (Balochistan) (Anderson 1999; Khan 2004; Sindaco and Jeremcenko 2008). Lut block is an elongated territory with general NS trend extending from Jazmurian in the south to Gonabad in the north. This zone has a length of 800 km and 200-250 km width. In the main Lut block, only Permian limestone of the whole Paleozoic era is exposed. Shallow marine Mesozoic sedimentary rocks, as well as sporadic outcrops belonging to Shirgesht, Padeha, Sardar, and Jamal formations are exposed. Continental Neogene-Quaternary deposits cover the surface of Lut block (http://ngdir.ir; National Geosciences Database of Iran 2010). These specimens were collected at midnight when air temperature was between 25°C to 41°C. The vegetation is dominated by *Seidlitzia rosmarinus* and *Tamarix* sp. (Fig. 1.). Syntopic lizard species are *Bunopus tuberculatus*, *Teratoscincus keyserlingii*, and *Phrynocephalus maculatus maculatus*.

Discussion

Except for the description of this species from the east of Dasht-e-Lut by de Witte (1973) and reinvestigations by Szczerbak and Golubev (1996) and Anderson (1974, 1999), no additional information has been available until during fieldwork in the western area of Dasht-e-Lut, three specimens of *Rhinogecko misonnei* were collected. In pholidosis and coloration, specimens almost agree with the descriptions of *R. misonnei* given by Anderson (1999), Szczerbak and Golubev (1996), and Rastegar-Pouyani et al. (2006), except for the number of scales across abdomen (22-26 instead of 26-28), wider range of LVe; (120-127 instead of 120), and number of scales around dorsal tubercles (9-10 instead of 8-9).
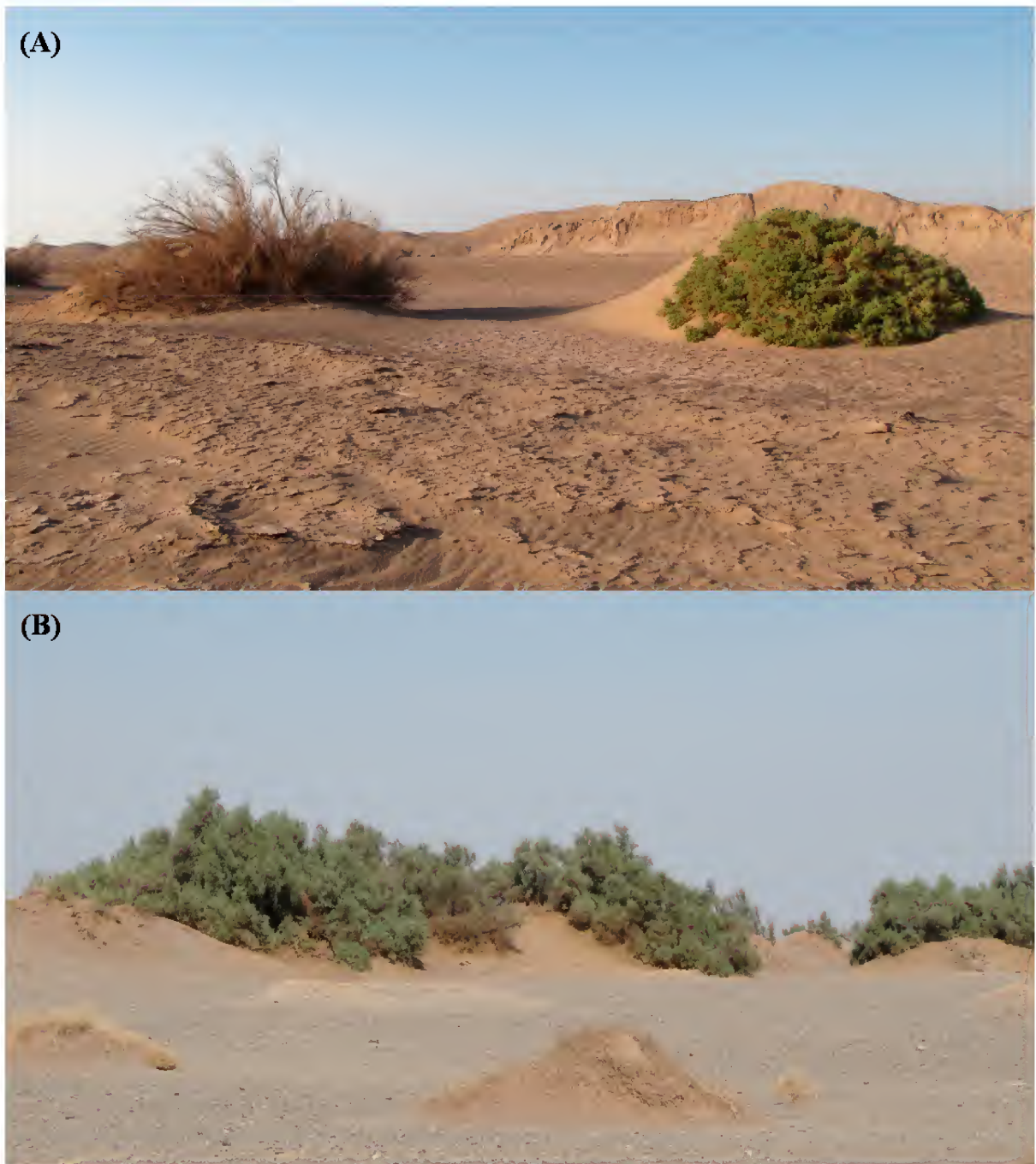
Figure 2. The habitat of *Rhinogecko misonnei*: (A) ZMSBUK 700 and 701; (B) ZMSBUK 702.
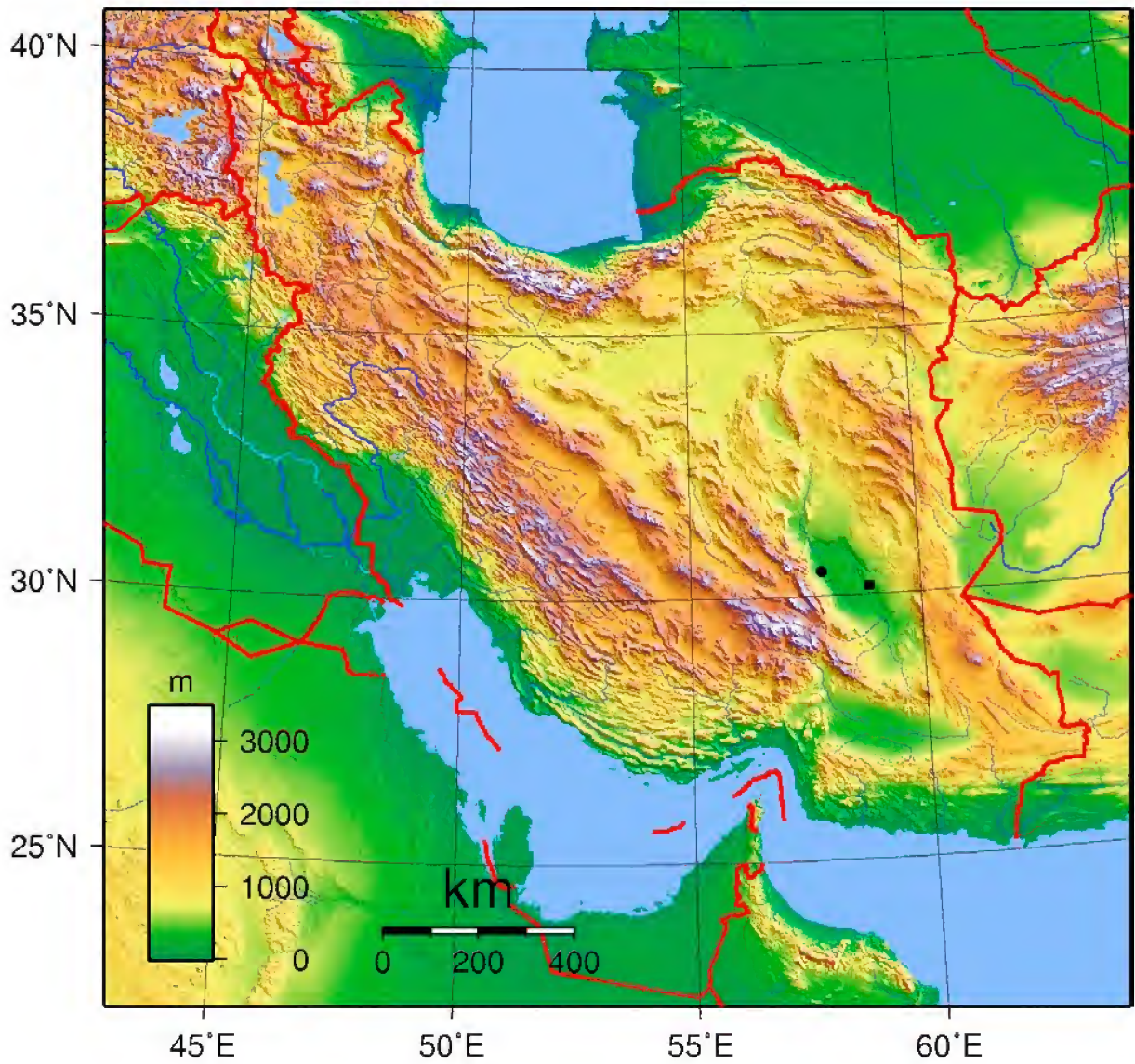
Figure 2. Distribution of *Rhinogecko misonnei* in Iran. Filled square: type locality (de Witte 1973). Filled circle: new locality.
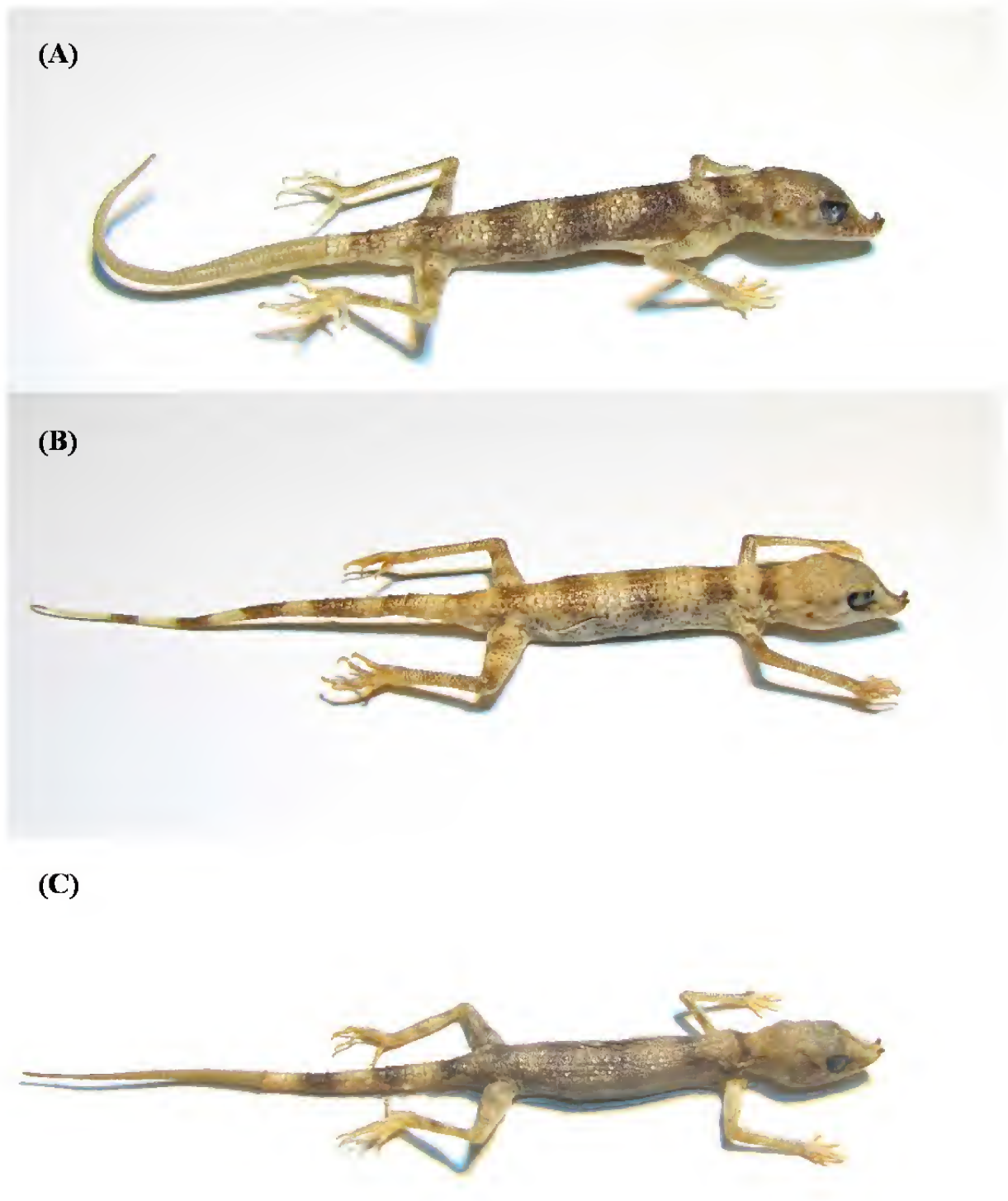
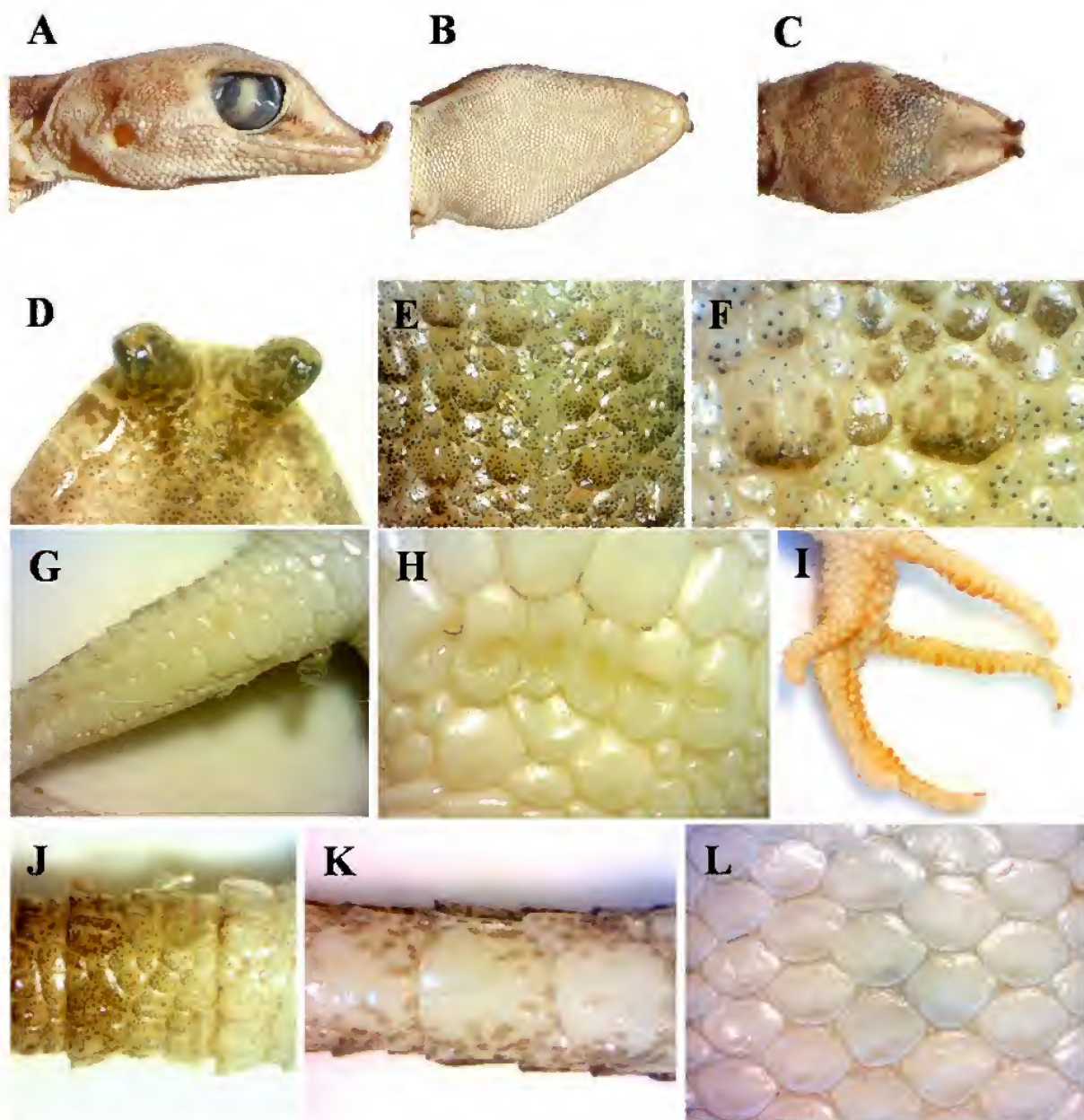**Figure 3.** *Rhinogecko misonnei.* (A) ZMSBUK 700; (B) ZMSBUK 701; (C) ZMSBUK 702.

Figure 4. *Rhinogecko misonnei*: (A) head from side; (B) head from below; (C) head from above; (D) snout from above; (E,F) dorsum; (G) femoral scale; (H) preanal pores; (I) ventral surface of digit; (J) tail from above; (K) tail from below; (L) belly.

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A new species of *Carinatogecko* (Sauria: Gekkonidae) from Ilam Province, western Iran

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Abstract.—A new keel-scaled gecko, *Carinatogecko ilamensis* sp. nov. (Squamata: Gekkonidae), is described from the western foothills of the Zagros Mountains in the Zarinabad region, Dehloran Township, Ilam Province, western Iran. It is a large *Carinatogecko* (snout-vent length exceeds 35 mm) which has distinct differences from other species of *Carinatogecko*: 1) postmentals absent, 2) dorsal crossbars broad and equal to, or wider than, interspaces; broader than dorsal crossbars of the three other *Carinatogecko* species. Some information about the habitat of the new taxon and the role of the Zagros Mountains in isolation and subsequent evolution of *Carinatogecko* is provided. Comparisons with other species of *Carinatogecko* and *Bunopus tuberculatus*, as representative of the genus *Bunopus*, are presented. An updated key to the genus *Carinatogecko* is given.

Key words. Gekkonidae, *Carinatogecko*, *C. ilamensis* sp. nov., *C. stevenandersoni*, *C. heteropholis*, *C. aspratilis*, Ilam Province, Iran

Introduction

The first specimen of the keel-scaled gecko was collected by Robert G. Tuck, Jr., and described by S. C. Anderson (1973) from 35 km east of Gachsaran, Fars Province, southwestern Iran. At that time, it was identified as *Bunopus aspratilis* (Anderson 1973: 355-358). Then, this taxonomic entity was elevated to the generic level, *Carinatogecko*, by Golubev & Szczerbak in 1981 (Golubev & Szczerbak 1981: 35-37; Szczerbak and Golubev 1996: 127-130).

The genus *Carinatogecko* Golubev & Szczerbak, 1981 encompasses three species: *C. aspratilis* (Anderson 1973) distributed in southern and southwestern Iran, *C. heteropholis* (Minton, Anderson, and Anderson 1970) distributed in a few areas in the western Zagros foothills of Iran and northeastern Iraq, and *C. stevenandersoni* Torki, 2011, distributed in Lorestan Province, western Iran (Torki 2011).

In this paper, we describe a new species of *Carinatogecko* Golubev & Szczerbak, 1981, point out some notes on the habitat type and flora of the environment, and compare the new species with other described species of *Carinatogecko*.

According to the available data (Leviton et al. 1992; Szczerbak and Golubev 1996; Anderson 1999; Fathin-

ia 2007; Rastegar-Pouyani et al. 2007; Červenka et al. 2010; Torki 2011), the new species belongs to the genus *Carinatogecko* Golubev & Szczerbak, 1981 based on having the following characters: All scales (except rostral, mental, postnasals, and upper and lower labials) strongly keeled; three nasal scales in contact with nostril; digits weakly angular, clawed, not dilated, not webbed nor ornamented, with keeled transverse subdigital lamellae; dorsal scales heterogeneous, small juxtaposed scales intermixed with tubercles; pupil vertical; tail segmented, caudal tubercles with bases in the middle of each segment, separated from or in contact with one another, separated by a ring of scales from the posterior margin of a segment.

Methods and materials

During fieldwork on amphibians and reptiles of Ilam Province, western Iran, two specimens of an unknown gecko were collected in Zarinabad region, Dehloran Township, Ilam Province (Fig. 1). The coordinates of the type locality are 32°57′51″ N, 47°03′23″ E and 543 m above sea level. The first specimen was collected active at 23:00 p.m. and the second on the following day after

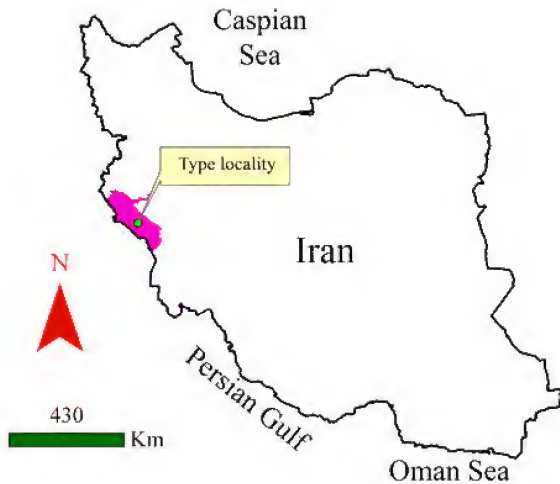**Correspondence.** *Email: [4]nasrullah.r@gmail.com*

Figure 1. The type locality of *Carinatogecko ilamensis* sp. nov. in Ilam Province, western Iran.

excavating a hole at the foot of a *Capparis spinosa* at 10:00 a.m.

Both holotype and paratype specimens were preserved in 95% ethanol and deposited in RUZM (Razi University Zoological Museum). Some of their characters differ significantly from those of the other three species of *Carinatogecko* (see below). The two unknown specimens were compared with the other three species of *Carinatogecko* (i.e., *C. heteropholis*, *C. aspratilis*, and *C. stevenandersoni*) as well as with the genus *Bunopus* (*B. tuberculatus*; Tables 1-2; Material examined).

Material examined

Bunopus tuberculatus (*n* = 5): RUZM-GB 140.1 – RUZM-GB140.5: Iran, Isfahan Province, Kashan.

Carinatogecko aspratilis (*n* = 3): RUZM-GC 10.1 – RUZM-GC10.3: Iran, Kermanshah Province.

Carinatogecko heteropholis (*n* = 22): RUZM-GC.110 – RUZM-GC.131: Iran, Ilam Province, Shirvan and Chardavol, Karezan, Sarab-e-Karezan village [33°44′ N, 46°29′ E and 1325 m above sea level].

Carinatogecko ilamensis sp. nov. (*n* = 2): RUZM-GC 120.1 – RUZM-GC 120.2: Iran, Ilam Province, Dehloran Township, Zarinabad region [32°57′51″ N, 47°03′23″ E and 543 m above sea level].

Results

Carinatogecko ilamensis sp. nov. (Figs. 2-7, 9b, 10a-d, 11c, 12d)

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Holotype

An adult male (RUZM-GC120.1), collected by Hamid Darvishnia on 8 August 2011, 500-600 m above sea level, on the western gypsum foothills of the Zagros Mountains, Zarin-Abad region, Dehloran Township,

Figure 2. The holotype of *Carinatogecko ilamensis* sp. nov. in natural habitat.
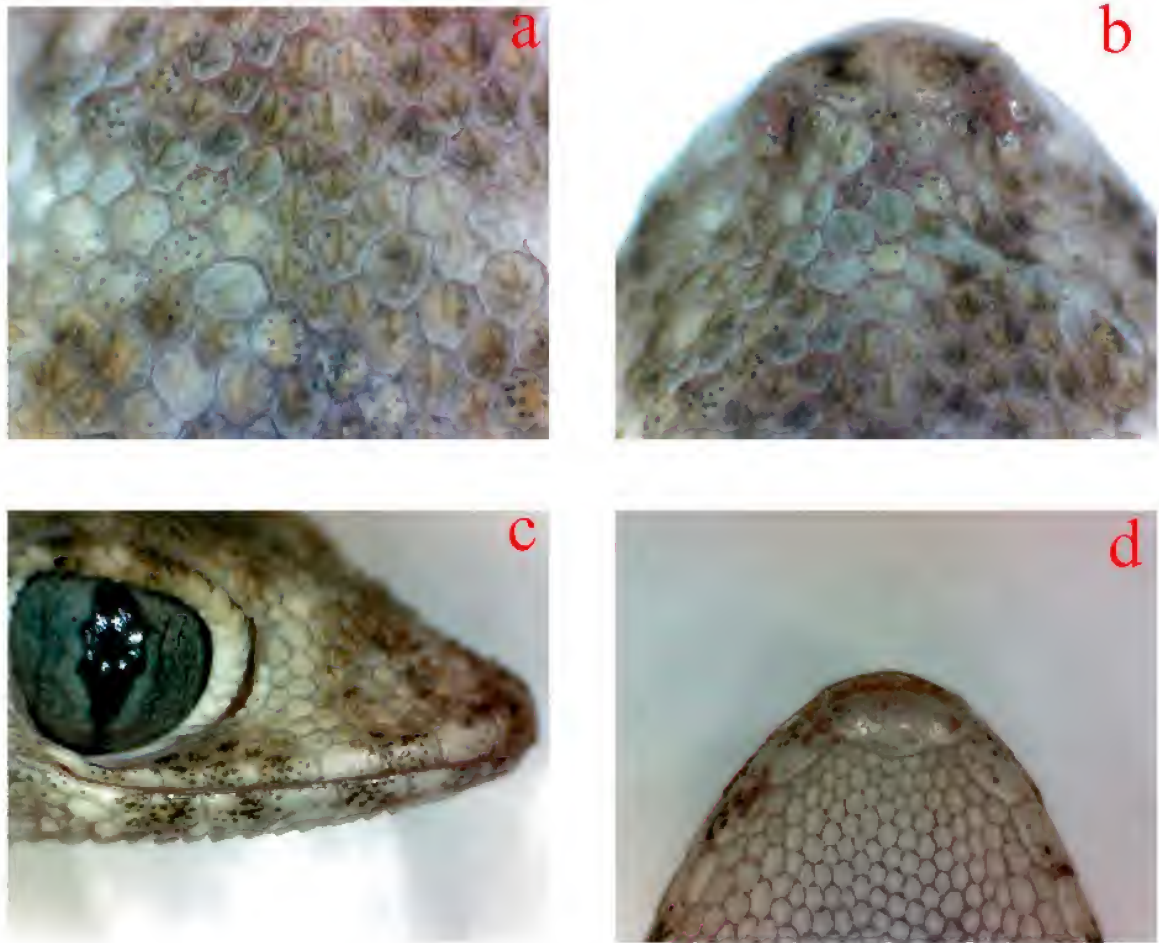
Figure 3. *Carinatogecko ilamensis* sp. nov. a) polyhedral and multi-keeled scales on snout, b) semidivided rostral and five scales between nostril, c) smooth supra- and infralabials, d) absence of postmentals.
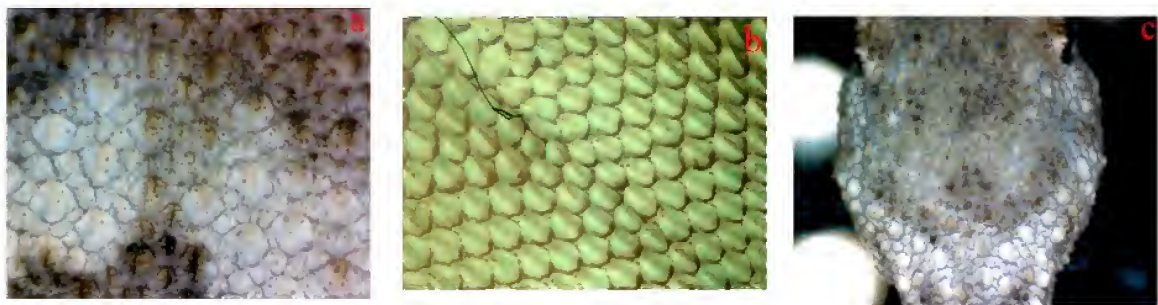
Figure 4. *Carinatogecko ilamensis* sp. nov. a) keeled scales and tubercles on dorsum, b) juxtaposed, blunt, keeled ventral scales, c) extending of dorsal tubercles onto nape and postorbital regions, but not onto occiput.
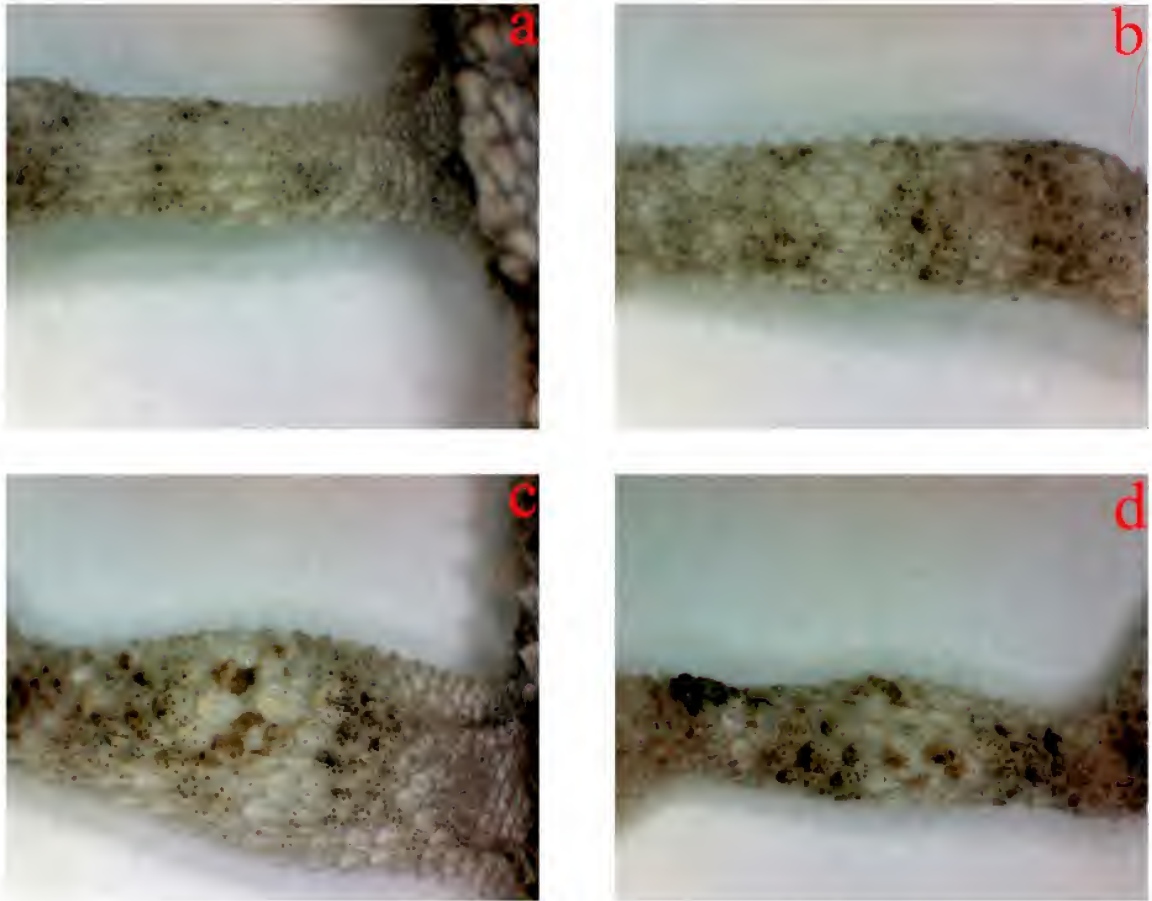
Figure 5. *Carinatogecko ilamensis* sp. nov. a-b) relatively homogenous scales on upper arm and forearm, respectively, c-d) larger dorsal scales and tubercles on thigh and shank, respectively.
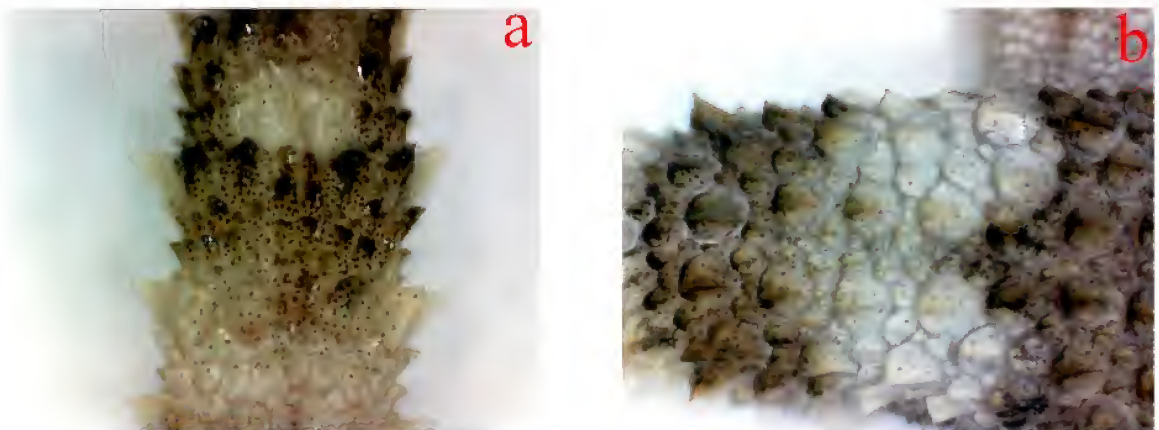
Figure 6a. *Carinatogecko ilamensis* sp. nov. a) mucronate, prominent tubercles on tail, b) comparison of tubercles on sacral region and proximal part of tail.
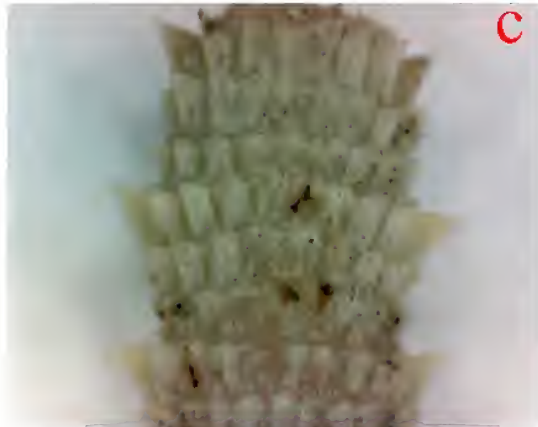
Figure 6b. *Carinatogecko ilamensis* sp. nov. c) keeled scales on ventral part of tail, d) blunt, keeled scales at the base of tail just behind the vent.

Figure 7. The paratype of *Carinatogecko ilamensis* sp. nov. Dorsal view (left), ventral view (right).

Figure 8. Habitat of *Carinatogecko ilamensis* sp. nov.
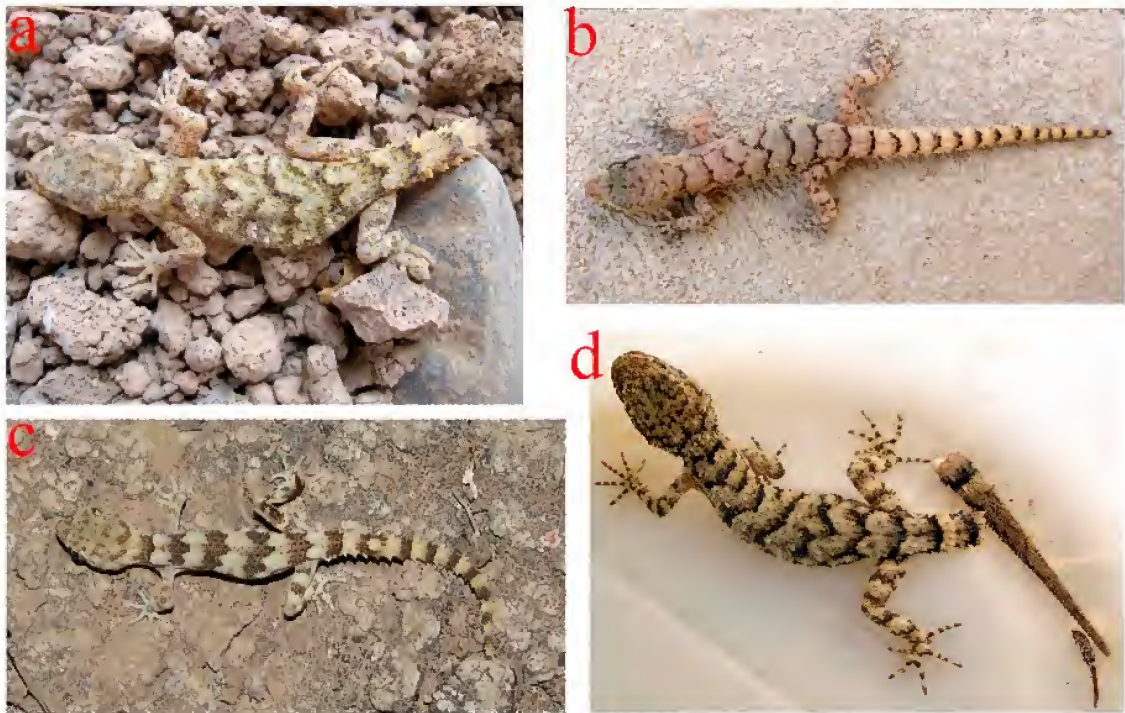
Figure 9. Comparison of dorsal pattern in a) *Carinatogecko aspratilis*, b) *C. heteropholis*, c) *C. ilamensis* sp. nov., and d) *C. stevenandersoni* (d from Torki 2011).
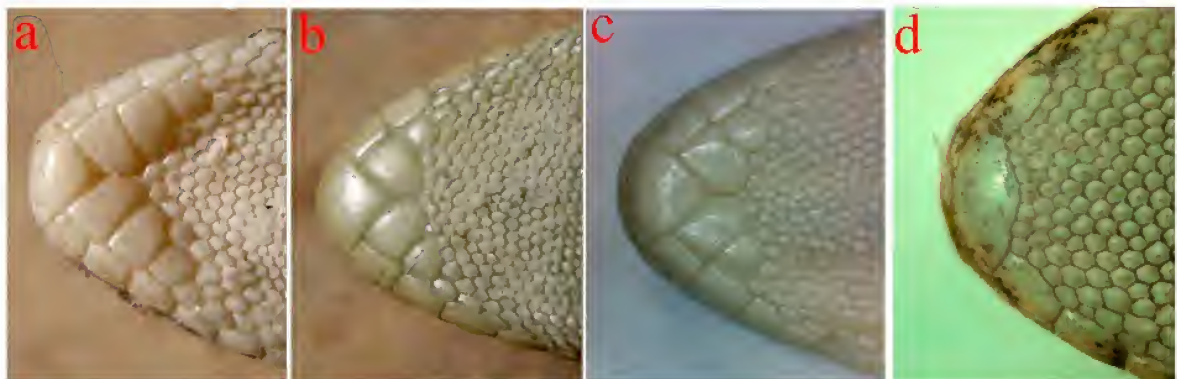
Figure 10. Comparison of mental shape and postmental region in all four species of *Carinatogecko*. a) *C. stevenandersoni*, b) *C. aspratilis*, c) *C. heteropholis*, and d) *C. ilamensis* sp. nov. (a and b from Torki 2011).

Figure 11. Comparison of dorsal pattern in (a) *Bunopus tuberculatus* and (b) *Carinatogecko ilamensis* sp. nov.
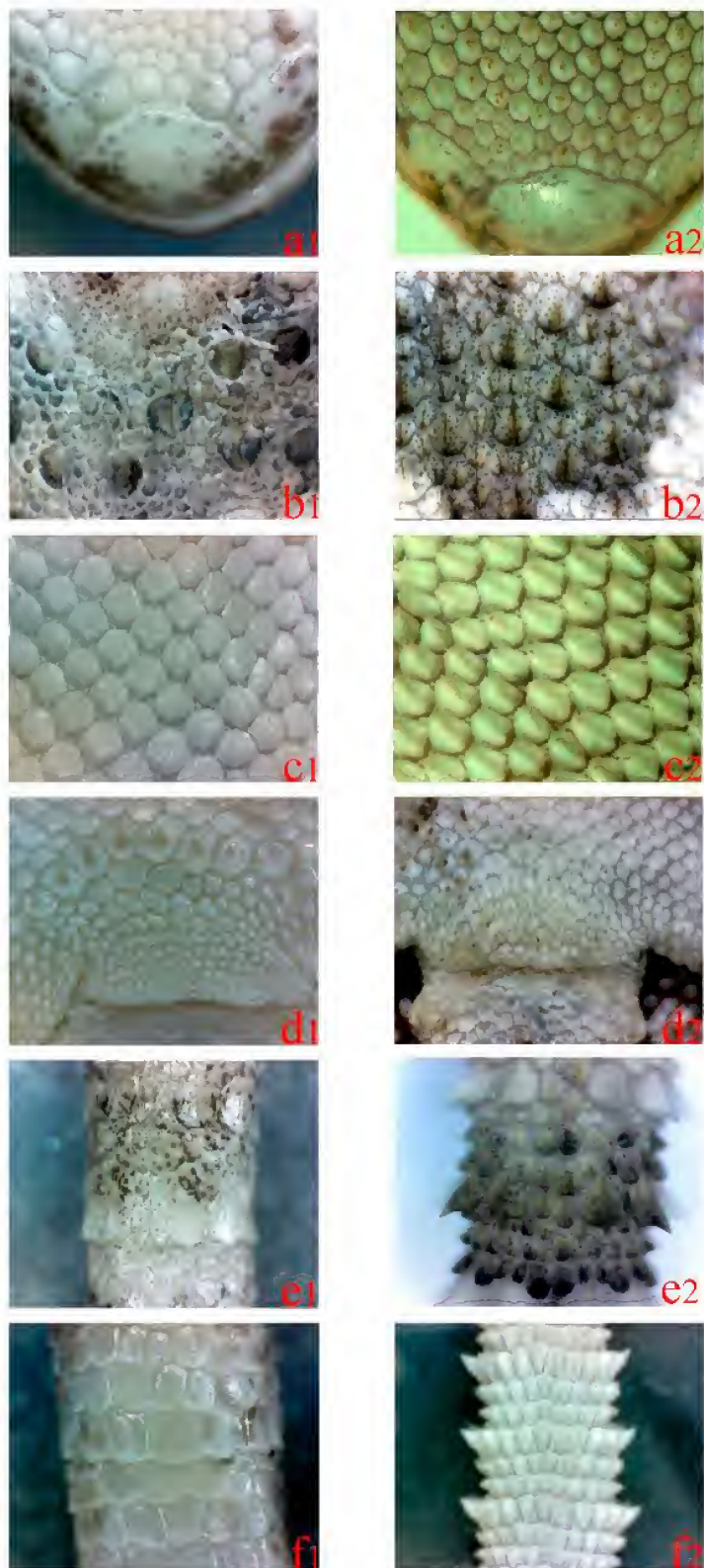
Figure 12. Comparison of a1-a2) mental and gular scales, b1-b2) dorsal pholidosis, c1-c2) ventral pholidosis, d1-d2) preanal pores, e1-e2) upper caudal region, and f1-f2) ventral region of tail in *Bunopus tuberculatus* (left) and *C. ilamensis* sp. nov. (right).

Table 1. Comparison of morphological characters between *C. ilamensis* sp. nov. and *Bunopus tuberculatus* (as the representative of the genus *Bunopus*, Blanford, 1874). Abbreviations: NGBM (number of granular scales behind mental); DS (dorsal scales); VS (ventral scales); PP (preanal pores in males); CDBIN (comparison of dorsal bands in relation to interspaces); DB (dorsal bands); IN (interspaces between dorsal bands); DCS (dorsal caudal scales); VCS (ventral caudal scales).

Characters	Carinatogecko ilamensis sp. nov.	Bunopus tuberculatus
NGBM	6-7 keeled gular scales	3-7 smooth gular scales
DS	large and strongly keeled	small, juxtaposed, and smooth
BS	small, keeled, not imbricate	small, smooth, subcircular, juxtaposed
PP	weakly developed, few in number	well developed, more in number
CDBIN	DB ≥ IN	DB much > IN
DCS	keeled	smooth
VCS	keeled, not platelike	smooth, some are platelike

Table 2. Comparison of morphological characters between *C. ilamensis* sp. nov. and the other three species of *Carinatogecko*. Abbreviations: PM (postmentals); SHM (shape of mental); OT (tubercles on occiput); SVS (status of ventral scales); CDBIN (comparison of dorsal bands in relation to interspaces); DB (dorsal bands); IN (interspaces between dorsal bands).

Characters	C. ilamensis sp. nov.	C. aspratilis	C. heteropholis	C. stevenandersoni
PM	absent	three pairs	two pairs	3-4 pairs
SHM	simple	pointed posteriorly	not pointed posteriorly	pointed posteriorly
OT	absent	present	present	present
SVS	not imbricate, not pointed	strongly imbricate, weakly pointed	weakly imbricate, not pointed	weakly imbricate, pointed
CDBIN	DB ≥ IN	DB < IN	DB < IN	DB < IN

Ilam Province, southwestern Iran at the coordinates of 32°57′51″ N and 47°03′23″ E.

Paratype

A subadult specimen (RUZM-GC120.2), collected by Behzad Fathinia on 9 August 2011 at the same locality as holotype.

Diagnosis

Snout-vent length (SVL) in holotype and paratype 36.5 and 29.3 mm respectively. As in all congeners, scales and tubercles all over the body strongly keeled (except upper and lower labials, nasals, rostral, and mental); dorsal scales heterogeneous, blunt; enlarged blunt tubercles on dorsum; mucronate tubercules on tail more prominent than tubercles on dorsum; homogeneous scales on forelimbs smaller than those on hindlimbs; tubercles on hindlimb few in number and all smaller than those on dorsum; polyhedral, multi-keeled scales on the head including rostral, prefrontal, and postfrontal regions; no postmental; mental bordered by 6-7 small keeled scales; scales on the ventral surface of head multi-keeled and morphologically different from those on ventral region of body and tail; ventrals equal to dorsals in length; ventral side of tail without large plate-like scales, but with keeled mucronate scales; 10-11 regular longitudinal rows

of tubercles on back; 30-32 ventral and ventrolateral scales from side to side.

Dorsal regions brownish, ventral regions whitish; complete regular chocolate crossbars across dorsum, limbs, digits, and tail; dorsal side of head spotted; occiput with a transverse dark bar; supra- and infralabials with dark spots; subdigital lamellae keeled.

Description of holotype

Snout-vent length (SVL) 36.5 mm.

a) head (Fig. 3): scales of frontal and supraocular regions toward snout are multi-keeled (in some scales up to six keels) and polyhedral, the keels meeting towards the tip of the scale; rostral smooth and semidivided posteriorly; nine smooth supralabials; nostril surrounded by five smooth scales including: rostral, first supralabial, and three postnasals; five scales between nostrils (first and fifth are smooth, the others keeled); mental smooth; no postmental; mental surrounded by seven small keeled scales posteriorly; seven smooth infralabials.

b) trunk (Fig. 4): all tubercles and scales of dorsum keeled, mostly blunt, a few mucronate; dorsal pholidosis heterogeneous; tubercles of dorsum extending to nape but absent in occiput; 11 longitudinal rows of tubercles on dorsum; dorsal tubercles surrounded by 8-10 smaller scales; 32 uniform ventrolateral and ventral keeled scales in a single transverse row to the point where they are dis-

tinguished from dorsolaterals by different color and size; ventral scales approximately equal to dorsals in length (0.5 mm); five preanal pores.

c) fore- and hindlimbs (Fig. 5): scales on dorsal side of forelimbs homogeneous and smaller than those on hindlimbs; no tubercle on forelimbs; few tubercles on hindlimbs; 17 keeled lamellae under the fourth toe.

d) tail (Fig. 6): caudal tubercles mucronate and more prominent than tubercles on dorsum; six tubercles at the middle of each whorl; tubercles in each whorl are in contact or separated by a small scale; tubercle of each whorl separated from preceding and succeeding whorls by three rows of scales; ventral side of tail without large plate-like scales, smaller blunt, keeled scales at the base of tail just behind the vent, but becoming strongly mucronate and keeled distally.

Color pattern (Figs. 2, 3c, 4b)

A transverse dark bar on occipital region; chocolate spots and stripes on head; dark fine spots on supra- and infralabials; dorsum light brown; five complete transverse blackish bars from nape to sacral region, equal to, or broader than, the lighter interspaces; complete dark crossbars on dorsal side of limbs and digits; 10 distinct brown transverse crossbars on the tail; ventral regions uniformly whitish.

Description of paratype

Snout-vent length (SVL) 29.3 mm.

a) head: rostral smooth and semidivided posteriorly; nostril surrounded by five smooth scales including rostral, first supralabial, and three postnasals; five scales between nostrils, the first and fifth smooth, others keeled; scales of prefrontal, pre- supra- and postoculars, and those behind ears are coarse and multi-keeled, their keels reducing toward parietal and occipital and gradually being replaced by uni-keeled scales; 10-10 smooth supralabials; a single smooth mental; no postmentals; mental surrounded posteriorly by six small keeled scales; 8-8 smooth infralabials.

b) trunk: blunt, keeled tubercles and scales on dorsum, few are mucronate; dorsal scales heterogeneous; 10 longitudinal rows of tubercles; dorsal tubercles surrounded by 8-9 keeled scales; 30 rows of keeled, uniform ventrolateral and ventral scales at the point where they are distinguished from dorsolaterals by different color and size; ventral keeled scales equal to dorsal ones.

c) fore- and hindlimbs: dorsal scales on forelimb homogeneous, smaller than those on hindlimb, tubercles on hindlimb smaller than those on dorsum; 16 keeled tubercles on the fourth toe.

d) tail: caudal tubercles mucronate and more prominent than dorsal tubercles; six pointed tubercles at the

middle of each whorl, in contact with or separated from each other by a small scale; each transverse row of tubercles separated from anterior and posterior rows of tubercles by three rows of keeled, usually blunt scales; all sides of regenerated tail covered with blunt, keeled scales; ventral side of tail without large, plate-like scales, covered by small, pointed, and keeled scales.

Color pattern (Fig. 7)

Dark stripes and spots on dorsal side of head, postorbital, frontal, infra- and supralabials; dorsum brownish white; six transverse chocolate bars on dorsum from nape to sacral region, the fifth partial, others complete; width of dark bars equal to or slightly smaller than light interspaces; dark crossbars on limbs and digits, not reaching ventral surfaces; ventral side of body whitish; dark transverse bars on tail, extending to lateral tail region.

Habitat (Fig. 8)

At the type locality, the natural habitat is composed of gypsum and lime sediments extending beyond the Iranian border westwards into Iraq. According to Mozaffarian (2008), a broad part of Ilam Province is a semi desert region, while other parts have temperate climate and very short winter frost. The type locality coincides with semidesert region.

Three climatic landscape and vegetation types occur in the province: 1) vast plains of lowland semiarid region, including plains and calcareous foothills, 2) more or less dry Zagrosian oak forest dominated by *Quercus brantii*, and 3) high mountains with cushion-like vegetation (Mozaffarian 2008). The type locality is located within the first of the three above-mentioned climatic types.

Different vegetation types mainly including grasses (Gramineae), bushes and shrubs (Capparidaceae: *Capparis spinosa*, *Cleome oxypetala*; Caryophyllaceae: *Gypsophyla linearifolia*, *G. pallida*; Chenopodiaceae: *Halocharis sulphurea*, *Noaea mucronata*, *Salsola imbricate*; Compositae: *Achillea conferta*; Rosaceae: *Amygdalus arabica*), and sparse trees (*Quercus brantii* and *Pistachia atlantica*) cover the area.

A permanent river (Gorazan River) flows through this area. Both specimens were collected in the foothills approximately 200-500 meters south of the river. The type locality is under grazing by sheep and goat herds belonging to the people of Cham-e-Sorkh village.

There is no information on the conservation status of *Carinatogecko ilamensis* sp. nov.

Sympatric lizards and snakes

Several species of lizards and snakes occur as sympatric, or syntopic, with *Carinatogecko ilamensis* sp. nov.

Among lizards: *Laudakia nupta, Trapelus lessonae, Eublepharis angramainyu, Asaccus elisae, Hemidactylus persicus, Acanthodactylus boskianus, Trachylepis aurata, Uromastyx loricata, Varanus griseus*; and among snakes: *Typhlops vermicularis, Spalerosophis diadema, Walterinnesia morgani, Macrovipera lebetina, Pseudocerastes urarachnoides*.

Distribution

Carinatogecko ilamensis sp. nov. is as yet known only from the type locality in the Zarinabad region, Dehloran Township, Ilam Province, western Iran (Fig. 1).

Etymology

Carinatogecko ilamensis sp. nov. is so named as it has been found, for the first time, in Ilam Province, western Iran.

Comparisons

Comparison with the genus *Bunopus* Blanford, 1874

The new species described here, at first glance, is similar to *Bunopus tuberculatus* Blanford, 1874 in the absence of postmentals and, to some extent, in overall body pattern (Figs. 9-10a). In order to reveal distinguishing characters separating *C. ilamensis* sp. nov. from *B. tuberculatus*, some photographs from different body parts of both taxa were taken and compared (Fig. 10). For this purpose, specimens of *B. tuberculatus* deposited in the RUZM were analyzed and photographed.

In both compared species, postmentals are absent and the mental has an irregular rear edge, bordered by 3-7 smooth granular scales in *B. tuberculatus* and 6-7 keeled granular scales in *C. ilamensis* sp. nov. (Fig. 10a); dorsum covered by small, juxtaposed, smooth scales intermixed with enlarged, keeled, trihedral tubercles in *B. tuberculatus*, and tubercles are much larger than surrounding scales, while dorsum is covered by keeled scales intermixed with strongly keeled tubercles in *C. ilamensis* sp. nov., and dorsal scales are approximately half the size of tubercles (Fig. 10b); belly is covered with small, smooth, subcircular, juxtaposed scales in *B. tuberculatus* and by small, keeled, approximately subimbricate scales in *C. ilamensis* sp. nov. (Fig. 10c); preanal pores present in males of both species and separated from ventrals by several rows of scales, weekly developed in *C. ilamensis* sp. nov. and lower in number than those of *B. tuberculatus* (Fig. 10d); upper caudal scales smooth in *B. tuberculatus* and keeled in *C. ilamensis* sp. nov.; caudal tubercles more prominent in *C. ilamensis* sp. nov.

than in *B. tuberculatus* (Fig. 10e); ventral part of tail in *B. tuberculatus* covered by smooth scales and some scales are more or less platelike and larger than adjacent ones, while in *C. ilamensis* sp. nov. scales of ventral part of tail are keeled, not plate-like, and almost the same size (Fig. 10f). Table 1 represents comparison of some major morphological characters between these two taxa.

Comparison with the other species of *Carinatogecko* Golubev & Szczerbak, 1981

In order to compare *Carinatogecko ilamensis* sp. nov. with the other three species of *Carinatogecko* (*C. aspratilis, C. heteropholis*, and *C. stevenandersoni*), the material deposited at Razi University Zoological Museum (RUZM-GC.110 – RUZM-GC.131) was examined and combined with information obtained from the literature (e.g., Leviton et al. 1992; Szczerbak and Golubev 1996; Anderson 1999; Fathinia 2007; Rastegar-Pouyani et al. 2007; Červenka et al. 2010; Torki 2011).

Based on the comparisons, *C. ilamensis* sp. nov. differs from its congeners by a combination of characters as follows: The color pattern is different from those of *C. heteropholis, C. aspratilis*, and *C. stevenandersoni* and dark transverse bands on dorsum in *C. ilamensis* sp. nov. are equal to, or wider than, light interspaces (in all other three species the darker bands are much narrower than interspaces; Fig. 11); the most obvious character differentiating *C. ilamensis* sp. nov. from the other three mentioned species comes from postmentals. *Carinatogecko ilamensis* sp. nov. has no postmentals (two pairs in *C. aspratilis*, and *C. heterophilis*, and 3-4 pairs in *C. stevenandersoni*; Fig. 12); the mental is not pointed posteriorly in *C. ilamensis* sp. nov. (the opposite is true for the three other species; Fig. 12); enlarged dorsal tubercles extend onto nape and postorbital regions but absent on occiput in *C. ilamensis* sp. nov. (extending on to occiput, upper head, to between eyes, and onto temporal region in *C. stevenandersoni*; extend onto occiput and run out before reaching the interorbital region in *C. heteropholis*, and run out in the occipital region in *C. aspratilis*); Ventral scales not imbricate in *C. ilamensis* sp. nov. (strongly imbricate in *C. aspratilis*, weakly imbricate in *C. heteropholis*, weakly imbricate in *C. stevenandersoni*); ventral scales not pointed in *C. ilamensis* sp. nov. (pointed in *C. stevenandersoni*, not pointed in *C. heteropholis*, weakly pointed in *C. aspratilis*); scales posterior to the labials not enlarged in *C. ilamensis* sp. nov. (not enlarged in *C. aspratilis*, enlarged in *C. heteropholis*, much enlarged in *C. stevenandersoni*); dorsal scales equal to ventrals in *C. ilamensis* sp. nov. (larger in *C. stevenandersoni*, equal or smaller in *C. heteropholis*, equal in *C. aspratilis*); number of subdigital lamellae under fourth toe 16-18 in *C. ilamensis* sp. nov (16-20 in *C. stevenandersoni*, 15 in *C. heteropholis*); SVL 36.53 mm in largest specimen of *C. ilamensis* sp. nov. (41.10 mm in *C. heteropholis*,

less than 27 mm in *C. aspratilis*, 36.49 mm in *C. steve-nandersoni*); all lower labials not divided in *C. ilamensis* sp. nov. (fourth and fifth lower labials divided in *C. ste-venandersoni*, not divided in both *C. heteropholis* and *C. aspratilis*).

Summary

Carinatogecko ilamensis sp. nov. is a new taxonomic entity within *Carinatogecko* Golubev & Szczerbak, 1981 based on having the following distinguishing characters: 1) mental not pointed posteriorly, 2) postmentals absent, 3) dorsal dark crossbars are equal to, or wider than, light interspaces, 4) scales on upper side of forearm are homogeneous. These significant differences are indicative of profound divergence of *C. ilamensis* sp. nov. from other keel-scaled geckos of the genus *Carinatogecko*.

Biogeography

According to some workers (e.g., Macey et al. 1998, 2000; Rastegar-Pouyani 1999a, b, c; Rastegar-Pouyani and Nilson 2002), occurrence of important and drastic vicariant events, including uplifting of the Zagros and Elburz Mountains in the late Tertiary, 15-9 million years before present (MYBP), have affected distribution and speciation of many of the Iranian Plateau lizards such as *Asaccus*, *Laudakia*, *Uromastyx*, *Trapelus*, and others.

The keel-scaled geckos of the genus *Carinatogecko*, with four known species so far, are mainly found in the Zagros Mountains and the adjacent foothills in western Iran. The first logical speculation concerning biogeography of the genus *Carinatogecko* is that they have had a widespread distribution as an ancestral taxon before the formation of the Zagros Mountains (15-9 MYBP). The Zagros orogeny has caused geographic isolation of ancestral populations leading to a reduced gene flow, providing great opportunities for genetic divergence and speciation in the keel-scaled geckos of the genus *Carinatogecko*.

Based on the available evidence, the Zagros Mountains can be regarded as the center of origin and diversification for *Carinatogecko*.

Key to species of the genus *Carinatogecko* Golubev & Szczerbak, 1981

Based on the available information (Leviton et al. 1992; Szczerbak and Golubev 1996; Anderson 1999; Fathinia 2007; Rastegar-Pouyani et al. 2007; Červenka et al. 2010; Torki 2011) and comparison of the examined material deposited in the RUZM, an updated key to the species of *Carinatogecko* is provided.

Diagnosis of the genus

All scales of the body, with exception of intermaxillaries, nasals, chin shields, and upper and lower labials, strongly keeled; three nasal scales contact nostril; digits weakly angularly bent, clawed, not dilated, not webbed, nor or-

Key to species of the genus *Carinatogecko* Golubev & Szczerbak, 1981

1a Postmentals absent .... *Carinatogecko ilamensis* sp. nov.

1b Postmentals present 2

2a Presence of 3-4 pairs of postmentals .... *Carinatogecko stevenandersoni* (Torki 2011)

2b Presence of two pairs of postmentals 3

3a Scales in middle of back distinctly larger than abdominals; caudal tubercles pointed, raised, with enlarged posterior facets; analogous dorsal tubercles present on forearms; 17-18 subdigital lamellae under the 4th toe .... *Carinatogecko aspratilis* (Anderson 1973)

3b Scales in middle of back negligibly smaller or alike in size to abdominals; caudal tubercles not pointed, posterior facets not raised; no analogous tubercles on forearms 4

4a Fifteen subdigital lamellae under the fourth toe; 11-13 bands on original tail .... *Carinatogecko heteropholis* (Minton, Anderson, and Anderson 1970)

4b Sixteen to seventeen lamellae under the fourth toe; nine bands across original tail .... *Carinatogecko* cf. *heteropholis* (Červenka, et al. 2010)

namented, with keeled transverse subdigital lamellae; dorsal pholidosis heterogeneous, small juxtaposed scales intermixed with tubercles; pupil vertical; tail segmented, caudal tubercles with bases in the middle of each segment, separated from posterior margin of segment by ring of scales (Anderson 1999: 144).

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Analysis of sexual dimorphism in the Persian long-tailed desert lizard, *Mesalina watsonana* (Stoliczka, 1872; Sauria: Lacertidae)

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Abstract.—*Mesalina watsonana* is one of the most widely distributed lacertid lizards of Iran. To investigate patterns of sexual dimorphism in this taxon, 206 (99 female, 107 male) adult specimens collected either from various regions of the Iranian Plateau during 2005-2008 or examined from museum collections were studied based on 19 morphometric and nine meristic characters. The results suggest that in *Mesalina watsonana*, body size could be the product of sexual and natural selection modified by ecological factors. Further, in all the studied populations, head size parameter has a more pronounced effect on the degree of sexual dimorphism than the length factors.

Key words. Lacertidae, *Mesalina watsonana*, sexual dimorphism, Iranian Plateau, head size, statistical analysis

Introduction

Between-sex differences in body size, coloration and morphology, so-called sexual dimorphism (SD), are widespread among reptiles (Schoener 1977; Berry and Shine 1980; Fitch 1981; Stamps 1983; Gibbons and Lovich 1990; Shine 1991). Several hypotheses attempt to explain the evolution of sexual dimorphism. Shine (1989) reviewed the literature and recognized two alternative explanations for sexual dimorphism: "sexual selection" and "intraspecific niche divergence."

Sexual dimorphism is a much-studied topic in the lacertid lizard literature (Brana 1996; Fitch 1981; Gvozdik and Boukal 1998; Molina-Borja 2003; Molina-Borja and Rodriguez-Dominguez 2004; Herrel et al. 2002; Kaliontzopoulou et al. 2007, 2010a, 2010b; Roitberg 2007). Sexual head size dimorphism is common in lacertid lizards, where an increased male head size may simultaneously be important in intersexual interactions (e.g., male-male combat, territorial contests; Trivers 1976; Fitch 1981; Anderson and Vitt 1990; Mouton and Van Wijk 1993; Bull and Pamula 1996; Censky 1995), intersexual interactions (copulatory bites, Herrel et al. 1996), and resource partitioning (e.g., males being able to eat larger prey than female conspecifics; Schoener 1967 and 1977; Stamps 1977; Best and Pfaffenberger 1987; Preest 1994).

Mesalina, a monophyletic group with 14 species, is a widespread lacertid occurring throughout the Saharo-Sindian region from North Africa to Pakistan (Kapli et al. 2008). Based on recent literature, *M. watsonana* is one of the two species of *Mesalina* whose occurrence has been confirmed in Iran. *Mesalina watsonana* is distributed widely on the Iranian Plateau and extends as far north as southern Turkmenistan and occurs in Afghanistan at elevations below 2500 m. This lizard is abundant on hard soils of plains and alluvial fans throughout much of Iran and is found on hillsides, valleys, and along stream courses. It is absent only in high mountains, along the Caspian coast and in the Azerbaijans as well as Kurdistan and Kermanshah provinces (Anderson 1999; Rastegar-Pouyani et al. 2007).

Little information is available on inter-population variation and habitat of *Mesalina watsonana* in Iran except that vegetation in areas where it occurs is usually scanty desert or steppe shrub, or areas stripped bare of perennial vegetation. To date no detailed information has been reported on morphometric and pholidotic differences between males and females in Iranian populations of *Mesalina watsonana*.

In this study, different aspects of sexual dimorphism in *Mesalina watsonana* are analyzed and discussed.

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Table 1. The morphological (19 morphometric and nine meristic) characters examined in both sexes of *Mesalina watsonana*.

Characters	Definition
SVL	Snout-vent length (from tip of snout to anterior edge of cloaca)
TL	Tail length (from posterior edge of cloaca to tip of tail)
LHF	Trunk length (distance between hindlimb and forlimb)
HL	Head length (from tip of snout to the posterior edge of tympanum)
HH	Head height (maximum distance between upper head and lower jaw)
HW	Head width (distance between posterior eye corners)
LFL	Length of forelimb (from top of shoulder joint to tip of 4th finger)
LHL	Length of hindlimb (from hip joint to tip of 4th toe)
LFO	Length of femur (from hip joint to top of knee)
LA	Length of tibia (from top of knee to beneath wrist)
EL	Length of eye (distance from anterior corner to posterior corner to its posterior)
RED	Snout length (from tip of nostril to anterior corner of eye)
EED	Distance between posterior edge of eye and tympanum
NL	Length of neck (distance between posterior edge of tympanum and shoulder joint)
TD	Tympanum diameter (largest size)
IOR	Interorbital distance (largest size)
LV	Length of cloaca crevice (largest size)
LBT	Length of widest part of tail base
LWB	Length of widest part of belly
NSL	Number of labial scales anterior to the center of eye on the right side of head
NIL	Number of scales on the right lower labial region
NGS	Number of gular scales in a straight median series
NCS	Number of collar scales
NEE	Number of scales between posterior edge of eye and tympanum
NVS	Number of transverse series of ventral scales counted in straight median series between collar and the row of scales separating the series of femoral pores
NDS	Number of dorsal scales across midbody
SDLT	Number of subdigital lamellae along underside of 4th toe (defined by their width, the one touching the claw included), counted bilaterally
NFP	Number of femoral pores, counted bilaterally

Methods and materials

Source of material

We examined more than 250 specimens of *M. watsonana* from its range on the Iranian Plateau (see Appendix). Of these, 207 undamaged and fully-grown adults (107 males and 99 females) were selected for the analyses. The specimens were obtained from two sources: 1) our own material collected in various parts of the Iranian Plateau during field work in 2006-2008. The collected materials are deposited at the Razi University Zoological Museum (RUZM). 2) Museum material borrowed from various museum collections throughout Iran, such as Iran National Natural History Museum (MMTT), Razi University Zoological Museum (RUZM), Zoological Museum of Tarbiat Moallem University of Sabzevar (SUZM), and Tehran University Zoological Museum (ZUTC).

Statistical analysis

All the specimens were examined for 19 morphometric and nine meristic characters (Table 1). Metric characters were evaluated using vernier calipers with measurements taken to the nearest 0.1 millimeter. During the sampling time some females were gravid and apparently had broader abdomens, thus width of body was not used in analysis. Data analysis was performed using parametric analyses after the assumptions of this analysis were checked and found to be met. Statistical analyses were performed using the SPSS (16) and S-Plus (8) for Windows.

All specimens used for the study of between-population variability in sexual dimorphism come from a limited geographic area, thus belonging to the same pop-
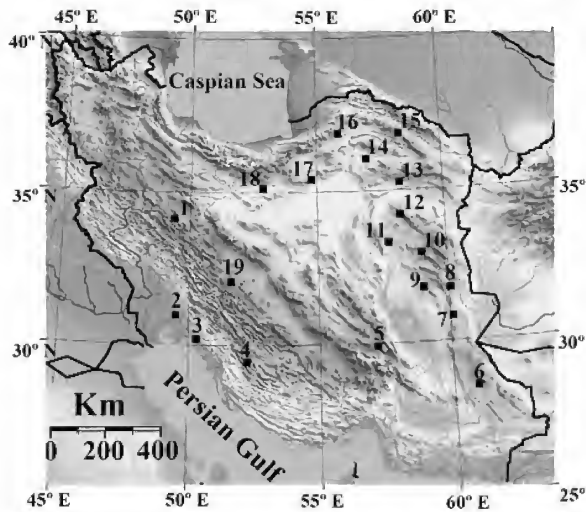
Figure 1. Geographic distribution of 19 Operational Taxonomic Units (OTU) of *Mesalina watsonana* used in this study.

Table 2. The localities of 19 OTUs of the *Mesalina watsonana* complex used in this study.

OTUs	Locality	Sample size	
		Female	**Male**
1	Arak, Markazi Province	2	4
2	Izeeh, Khuzestan Province	8	7
3	Dehdasht, Kohkiloye and Boyer Ahmad Province	7	6
4	Shiraz, Fars Province	6	3
5	Kerman, Kerman Province	5	10
6	Khash, Sistan- Balochestan Province	4	3
7	Nehbandan, Southern Khorasan Province	4	4
8	Sarbishee, Southern Khorasan Province	7	7
9	Birjand, Southern Khorasan Province	10	5
10	Ghaen, Southern Khorasan Province	3	2
11	Ferdoos, Southern Khorasan Province	4	3
12	Gonabad, Khorasan Razavi Province	13	4
13	Kashmar, Khorasan Razavi Province	6	1
14	Sabzevar, Khorasan Razavi Province	3	5
15	Ghochan, Khorasan Razavi Province	2	3
16	Jajarm, Northern Khorasan Province	4	3
17	Khartooran, Semnan Province	7	8
18	Semnan, Semnan Province	7	7
19	Unknown region in Central Zagros	5	14
Total		107	99

ulation of animals (analysis of sexual dimorphism was carried out in three separate geographic regions of Iran; Fig. 1 and Table 2).

1. Eastern populations (OTUs: 6, 7, 8, 9, 10, 11, 12, 13)
2. Northeastern populations (OTUs: 14, 15, 16, 17, 18)
3. Zagros populations (OTUs: 1, 2, 3, 4, 5, 19)

To reveal dispersion patterns among morphological characters of both sexes, descriptive statistical parameters, including minimum, maximum, mean, and standard error were employed separately for each region.

The Analysis of Variance (ANOVA) was used to carry out pair-wise comparisons of the characters between males and females and significant characters were plotted using the error bars.

Principal Components Analysis (PCA) was used based on a correlation matrix of 17 characters for each region separately. In order to show the contribution of morphological characters to sexual dimorphism, all individuals of each region were subjected to a Principal Components Analysis.

Discriminant Function Analysis (DFA) was also used as a tool to determine which variable discriminates between males and females. To investigate the importance of various parameters in sexual dimorphism, we calculated the two components of head and length factors in each population and then ran the DFA for each population separately based on the following formula:

Head size parameter = $(0.902 \times HL) + (0.904 \times HH) + (0.890 \times HW) + (0.763 \times NL) + (0.790 \times IOR) + (0.863 \times EED) + (0.806 \times RED)$

Length size parameter = $(0.896 \times SVL) + (0.818 \times LHF) + (0.900 \times LFL) + (0.831 \times LA) + (0.884 \times LHL) + (0.905 \times LFO)$

The weight of each character was gained from the PCA.

Results

Descriptive Analysis

Descriptive parameters of morphometric and meristic characters are presented for males and females separately in each region. The comparison of characters between male and female individuals is presented in Table 3.

Univariate Analysis

The results of Analysis of Variance (ANOVA) carried out for intra-sexual comparison of meristic and morphometric characters are presented in Table 4.

Analysis of Variance revealed significant differences in 13 morphometric (HL, HH, HW, LFL, LA, LHL, LFO,

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Table 3. Descriptive parameters of some morphological characters including minimum, maximum, mean, and standard error in *Mesalina watsonana*.

Characters		Eastern Populations (Female = 28, Male = 45)		Northeastern Populations (Female = 27, Male = 29)		Zagros Populations (Female = 44, Male = 33)	
		Mean ± std. error	Minimum-Maximum	Mean ± std. error	Minimum-Maximum	Mean ± std. error	Minimum-Maximum
HL	Female	9.4971 ± 0.33823	7.42-16.58	9.6222 ± 0.16429	8.13-11.26	10.5677 ± 0.15922	8.83-13.54
	Male	10.5913 ± 0.20579	7.58-13.90	10.6345 ± 0.18343	9.00-12.78	11.6036 ± 0.21712	8.17-13.74
HH	Female	3.8500 ± 0.12321	2.82-5.19	4.0000 ± 0.11171	2.70-4.91	4.4725 ± .09356	3.15-6.55
	Male	4.4184 ± 0.10492	3.05-5.80	4.6672 ± 0.07675	4.06-5.72	4.7864 ± 0.11501	3.53-5.69
HW	Female	5.6618 ± 0.15458	4.00-6.94	5.9596 ± 0.13134	4.39-7.16	6.3482 ± 0.09748	5.17-7.78
	Male	6.3942 ± 0.12450	4.76-7.91	6.5686 ± 0.09957	5.18-7.93	7.0758 ± 0.13050	5.32-8.32
LFL	Female	13.4314 ± 0.34455	10.10-17.12	14.3822 ± 0.24598	12.25-17.00	15.4589 ± 0.23607	12.93-20.51
	Male	14.8482 ± 0.29742	10.95-18.87	15.8286 ± 0.31250	12.80-19.28	16.9803 ± 0.33027	11.84-19.98
LHL	Female	24.0686 ± 0.67549	16.98-31.07	25.3215 ± 0.43876	19.92-29.34	28.6845 ± 0.35742	22.91-34.15
	Male	26.9444 ± 0.49379	20.17-32.86	28.3431 ± 0.59926	21.58-35.00	31.4548 ± 0.49111	23.80-35.63
LFO	Female	6.9643 ± 0.22032	4.77-9.40	8.0878 ± 0.19763	6.15-9.97	9.1268 ± 0.18047	6.72-11.11
	Male	8.1504 ± 0.17475	5.95-10.41	9.0341 ± 0.17226	7.48-11.49	10.3670 ± 0.22624	7.86-13.49
IOR	Female	4.1086 ± 0.10835	3.00-5.08	4.1374 ± 0.08482	3.14-5.10	4.4623 ± 0.06698	3.79-5.54
	Male	4.4638 ± 0.08422	3.24-5.83	4.5410 ± 0.07131	3.94-5.26	4.6742 ± 0.07675	3.87-5.46
EED	Female	3.3736 ± 0.10541	2.23-4.80	3.5007 ± 0.09999	2.45-4.51	4.0720 ± 0.07063	3.15-4.92
	Male	3.9462 ± 0.11887	2.81-7.15	4.2107 ± 0.08289	3.32-5.11	4.4452 ± 0.08917	3.20-5.11
RED	Female	3.9486 ± 0.11848	2.60-5.42	4.5967 ± 0.10457	3.63-5.93	4.8602 ± 0.09168	3.53-6.18
	Male	4.5304 ± 0.10906	2.92-5.83	5.0383 ± 0.07962	4.00-6.17	5.3382 ± 0.12157	3.54-6.29
LV	Female	3.3446 ± 0.11795	2.24-4.61	3.3730 ± 0.10538	2.56-4.89	3.8791 ± 0.10236	2.75-5.89
	Male	3.9807 ± 0.09483	2.89-5.22	4.5814 ± 0.13158	3.52-6.25	4.7927 ± 0.15846	3.09-7.27
LBT	Female	3.9611 ± 0.12691	2.67-5.28	4.2741 ± 0.11800	3.15-5.52	4.5425 ± 0.09579	3.65-6.85
	Male	4.8444 ± 0.13169	3.36-6.90	5.4131 ± 0.13380	3.88-6.89	5.8264 ± 0.20259	3.70-7.68
NVS	Female	29.7143 ± 0.32472	27.00-34.00	30.3704 ± 0.38913	27.00-35.00	29.3864 ± 0.29480	25.00-35.00
	Male	28.9333 ± 0.21415	26.00-33.00	29.1724 ± 0.35466	25.00-33.00	28.5152 ± 0.27566	26.00-33.00

Table 4. The ANOVA based intra-sexual comparison of meristic and morphometric characters in three different groups of populations of *Mesalina watsonana*.

	Eastern					Northeastern					Zagros				
	Sum of squares	df	Mean square	F	Sig.	Sum of squares	df	Mean square	F	Sig.	Sum of squares	df	Mean square	F	Sig.
SVL	285.448	1	285.448	8.806	0.004	45.877	1	45.877	3.179	0.081	23.934	1	23.934	0.894	0.347
HL	22.909	1	22.909	9.446	0.003	7.470	1	7.470	12.600	0.001	20.236	1	20.236	15.527	0.000
HH	5.537	1	5.537	11.950	0.001	4.942	1	4.942	19.750	0.000	1.858	1	1.858	4.563	0.036
HW	9.652	1	9.652	13.847	0.000	3.025	1	3.025	9.073	0.004	9.982	1	9.982	20.819	0.000
LFL	2.989	1	2.989	0.202	0.654	3.840	1	3.840	0.453	0.504	43.650	1	43.650	14.839	0.000
LHL	170.396	1	170.396	12.918	0.001	70.025	1	70.025	11.695	0.001	13.433	1	13.433	1.365	0.246
LFO	28.408	1	28.408	17.970	0.000	7.613	1	7.613	9.089	0.004	29.002	1	29.002	18.804	0.000
IOR	2.438	1	2.438	7.812	0.007	1.802	1	1.802	10.004	0.003	0.847	1	0.847	4.320	0.041
LV	8.779	1	8.779	18.005	0.000	16.725	1	16.725	47.084	0.000	15.741	1	15.741	25.476	0.000
LBT	15.852	1	15.852	20.376	0.000	13.075	1	13.075	37.487	0.000	31.082	1	31.082	38.404	0.000
NVS	13.949	1	13.949	4.345	0.040	25.274	1	25.274	6.510	0.014	14.313	1	14.313	4.387	0.040
RED	7.230	1	7.230	13.384	0.000	1.311	1	1.311	6.193	0.016	4.308	1	4.308	10.254	0.002
EED	7.069	1	7.069	13.727	0.000	5.282	1	5.282	22.693	0.000	2.625	1	2.625	11.039	0.001
TD	0.727	1	0.727	5.314	0.024	1.063	1	1.063	5.089	0.029	0.275	1	0.275	2.487	0.119
LA	3.585	1	3.585	4.417	0.039	2.808	1	2.808	2.910	0.094	6.305	1	6.305	7.063	0.010
NL	6.603	1	6.603	4.873	0.030	2.304	1	2.304	2.751	0.104	5.103	1	5.103	4.197	0.044
NCS	0.563	1	0.563	0.262	0.610	1.206	1	1.206	.673	0.416	8.766	1	8.766	4.007	0.049
NDS	0.008	1	0.008	0.001	0.976	34.268	1	34.268	3.394	0.072	0.848	1	0.848	0.078	0.780
NEE	0.872	1	0.872	0.736	0.394	6.376	1	6.376	4.384	0.042	3.040	1	3.040	1.419	0.237
SDLT	0.010	1	0.010	0.004	0.947	5.180	1	5.180	1.712	0.197	29.464	1	29.464	7.819	0.007
NFP	6.154	1	6.154	6.083	0.016	1.133	1	1.133	.680	0.414	7.456	1	7.456	7.912	0.006

Table 5. Factor loadings on the first three principal components, extracted from the separated correlation matrix of morphological characters, for males and females of *Mesalina watsonana*.

Characters	Northeastern			Eastern			Zagros		
	PC1	PC2	PC3	PC1	PC2	PC3	PC1	PC2	PC3
Zscore (SVL)	0.813	0.070	0.176	0.927	0.059	-0.048	-	-	-
Zscore (HL)	0.882	0.040	-0.048	0.883	0.209	-0.039	0.936	0.029	0.048
Zscore (HH)	0.866	-0.110	-0.091	0.917	0.190	0.072	0.848	-0.168	-0.090
Zscore (HW)	0.890	-0.177	0.027	0.915	0.029	0.055	0.808	0.081	-0.133
Zscore (LFL)	0.774	0.276	0.226	0.920	-0.044	-0.102	0.795	0.060	0.244
Zscore (LA)	-	-	-	0.822	-0.049	0.252	0.678	-0.317	0.460
Zscore (LHL)	0.803	0.310	0.060	0.922	0.090	-0.101	0.842	0.112	-0.029
Zscore (LFO)	0.812	0.035	0.004	0.940	0.030	0.002	0.763	-0.007	0.366
Zscore (TD)	0.630	-0.481	0.276	0.699	0.011	0.339	-	-	-
Zscore (NL)	-	-	-	0.761	-0.128	-0.046	0.633	-0.388	0.009
Zscore (IOR)	0.818	-0.109	0.279	0.846	0.036	0.084	0.558	-0.374	-0.370
Zscore (EED)	0.811	-0.015	-0.190	0.816	-0.016	-0.147	0.836	-0.076	-0.016
Zscore (RED)	0.754	0.098	0.014	0.765	-0.229	-0.053	0.869	0.082	0.231
Zscore (LV)	0.814	-0.142	-0.290	0.855	-0.190	0.007	0.794	0.059	-0.253
Zscore (LBT)	0.858	0.135	-0.114	0.885	-0.162	-0.070	0.872	0.089	-0.191
Zscore (NDS)	-0.059	0.700	-0.439	-0.005	0.850	0.470	-	-	-
Zscore (NVS)	-0.331	0.377	0.758	-0.153	-0.566	0.749	-0.273	0.207	0.613
Zscore (NCS)	-	-	-	-	-	-	0.383	0.690	-0.227
Zscore (NEE)	0.282	0.588	0.099	-	-	-	-	-	-
Zscore (SDLT)	-	-	-	-	-	-	0.284	0.849	0.045
Eigenvalues	8.77	1.49	1.16	11.14	1.27	1.03	8.49	1.70	1.16
Accumulated percent of trace	54.80	64.14	71.39	65.54	73.00	79.10	53.10	63.74	70.96

NL, IOR, EED, RED, LV, and LBT) and four meristic characters (NFP, SDLT, NCS, and NVS) between the two sexes at the level of 95% ($p < 0.05$) in the Zagros populations.

In the eastern populations, the ANOVA showed significant differences in 15 morphometric (SVL, HL, HH, HW, LFL, LA, LHL, LFO, NL, TD, IOR, EED, RED, LV, and LBT) and two meristic characters (NVS and NDL) between the two sexes at the level of 95% ($p < 0.05$), and in the northeastern populations, the ANOVA revealed significant differences in 13 morphometric (SVL, HL, HH, HW, LFL, LHL, LFO, TD, IOR, EED, RED, LV, and LBT) and three meristic characters (NVS, NEE, and NDS) between the two sexes at the level of 95% ($p < 0.05$).

Some characters (HL, HH, HW, LFL, LHL, LFO, IOR, LV, LBT, NVS, RED, and EED) show significant differences ($p < 0.05$) between the two sexes. Most of these characters (HL, HH, HW, IOR, RED, and EED) are related to head size, so that males have greater absolute head size than the females in all the three studied populations (Figure 2A-D). Also, males have proportionately longer limbs (LFL, LHL, and LFO) than females.

Multivariate Analysis

Comparing the two sexes at multivariate level, the PCA was used plotting individual males and females from each of the three separated populations to explore the patterns of sexual dimorphism in each region.

For the entire three geographic regions most of characters loaded heavily on the first three components. The first component (PC1) is interpretable as a general body size factor providing a good measure of overall size. In almost all the OTUs, males tend to be larger than females in general body size and often have higher scale counts in various parts of body except NVS (number of transverse series of ventral scales, counted in strait median series between collar and the row of scales separating the series of femoral pores) which is lower in males. The first component (PC1) addresses 53-65% of the total variation within all three populations. In the case of the Zagros populations, the PC1 explains 53.1%, and the first three principal components address 70.9% of the total variation (Table 5). The magnitude and sign of the loadings on PC1 and PC2 show a consistent pattern between samples and the high degree of sexual dimorphism is easy to interpret (Figure 3A).
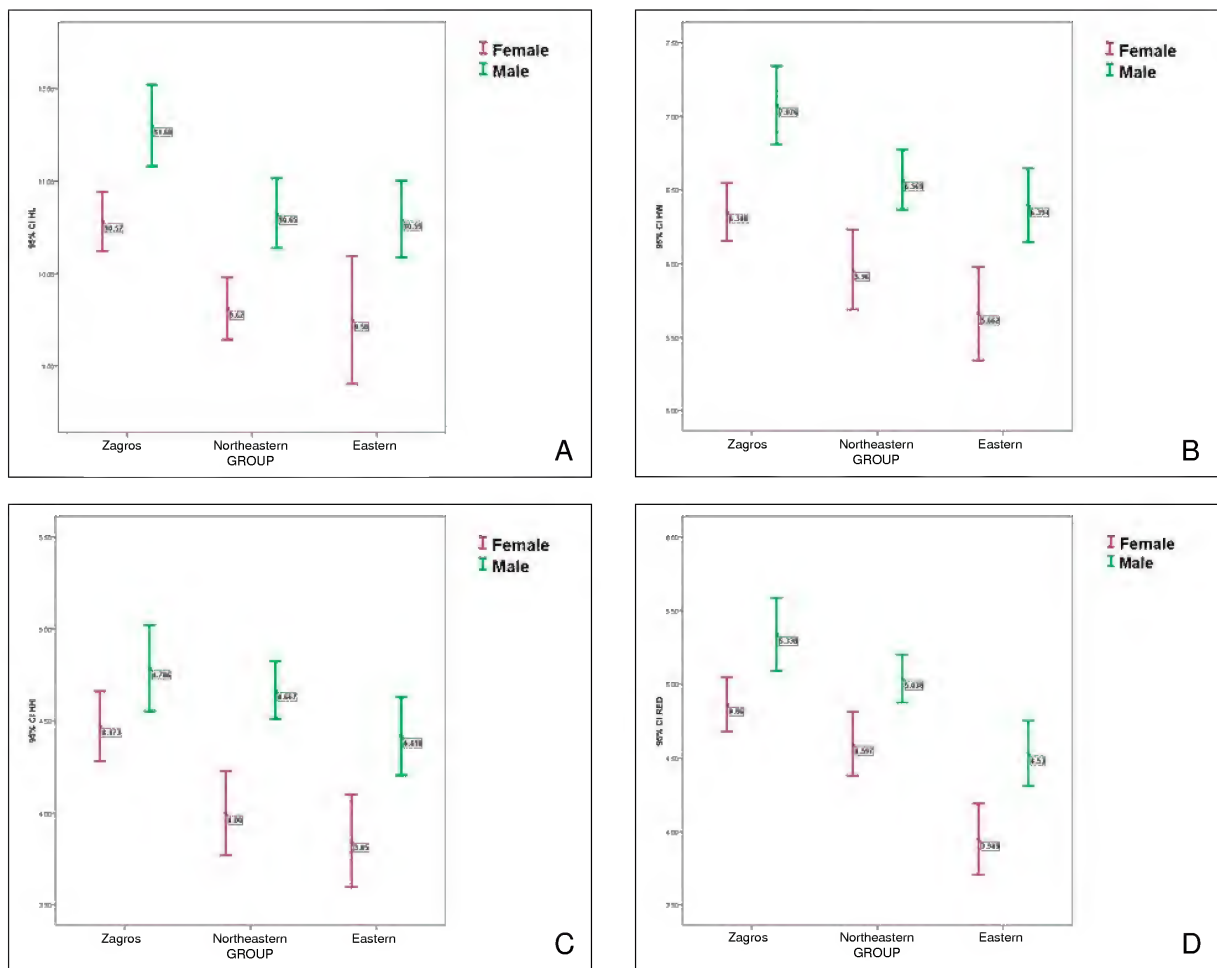
Figure 2. The mean and standard error (bars) for significantly different head size characters between males and females of *Mesalina watsonana*, revealed from the analysis of variance (ANOVA). Head length (A), head width (B), head height (C), and snout length (D).

In the northeastern populations, PC1 explains 54.1%, and the first three principal components address 71.4% of the total variation (Table 5). The magnitude and sign of the loadings on PC1 and PC2 show a consistent pattern between samples and the high degree of sexual dimorphism is easy to interpret (Figure 3B).

In the eastern populations, the PC1 explains 65.5%, and the first three principal components address 79% of the total variation (Table 5). The magnitude and sign of the loadings on PC1 and PC2 show no consistent pattern between samples and are difficult to interpret. In some instances PC3 does have a little contribution in discrimination between males and females (Figure 3C).

Discriminant Function Analysis (DFA)

Based on this analysis, head size parameter has more effect on sexual dimorphism than the length size parameter in all populations. Based on the Discriminant Function Analysis, the head size parameter could classify the original grouped cases almost correctly, so that 70.1% of the Zagros populations, 73.2% of the northeastern populations, and 67.1% of the eastern populations were correctly classified into their relevant groups. As well, based on this analysis, the length size parameter classified the original grouped cases almost correctly: 62.3% of the Zagros populations, 64.3% of the northeastern populations, and 64.4% of the eastern populations were correctly classified into their relevant groups. Although, the head size parameter separates the males and females better than the length size parameter, its effect is obviously related to environmental conditions. So that the head size in the eastern populations has less effect in separation in relation to the other populations. Interestingly in the eastern populations, the length size parameter also has a weak effect in separation of the groups.

Scatterplots of head length (HL) against the snout-vent length (SVL) for each population is shown in Figure 4A-C.

In the northeastern and Zagros populations, in an individual male and female with the same SVL, obviously
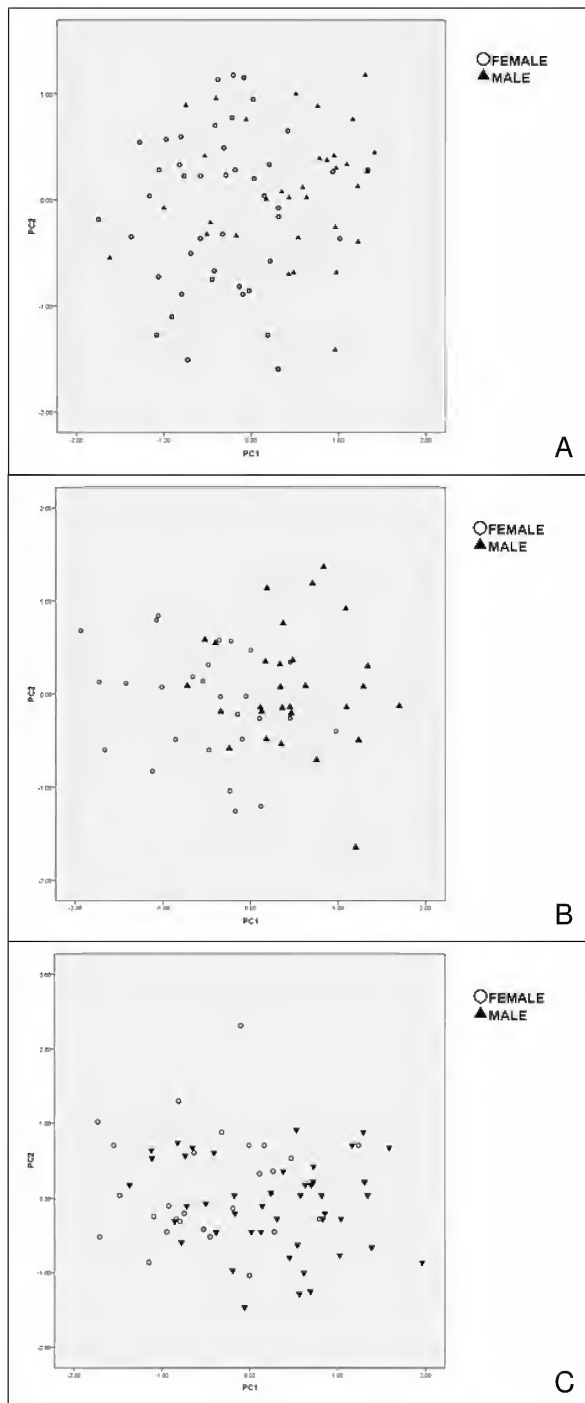
Figure 3. Ordination of individual male (▲) and female (○) specimens of the Zagros populations (A) Northeastern populations (B) Eastern populations (C) on the first two principal components.

the males having larger heads (HL) than the females, but in the eastern populations the head size of both sexes is nearly the same. This pattern is repeated in the other head size characters (HW, HH, IOR, RED, and EED) but with different influences. Finally we may conclude that

the rate of head size growth relative to the SVL growth, though not significantly different ($p > 0.05$) in all populations, was faster in males than in females (Fig. 4).

Discussion

Body size variation (e.g., SVL) among populations of lizards is a common phenomenon. Variation in body size has even been observed among individuals living in different habitats in the same population (Smith 1996 and 1998).

Variation in sexual dimorphism among populations is less well investigated; however, it is apparent that it does occur (McCoy et al. 1994; Molina-Borja et al. 1997). In *Mesalina watsonana*, interestingly in each group of populations we found a distinct pattern of sexual dimorphism (Table 4). Some characters (HL, HH, HW, LFL, LHL, LFO, IOR, LV, LBT, NVS, RED, and EED) show significant differences ($p < 0.05$) between the two sexes in all populations. Most of these characters (HL, HH, HW, IOR, RED, and EED) are related to head size.

Sexual differences in head size are common within the clade of lacertid lizards (e.g., Castilla et al. 1989; Brana 1996; Molina-Borja et al. 1997; Gvozdik and Boukal 1998; Huang 1998) with obvious implications. It is likely that sexual dimorphism in head size was present in a common ancestor of lacertids. We propose that sexual dimorphism in head size did not evolve *de novo* in *M. watsonana* but as a result of phylogenetic history. However, as demonstrated here, the actual extent of the dimorphism may be maintained through competition over mates (sexual selection) and environmental conditions (ecology). Environmental conditions (ecology, competition, and so on) affected the pattern of head size sexual dimorphism in different populations of *M. watsonana* in various regions of Iran. Our results illustrate that unlike other cases (Shine 1990; Stamps 1993; Gvozdik and Damme 2003), proximate environmental factors can be important determinants of sexual dimorphism in head size and other characters (ecological conditions having different effects on sexual dimorphism in different populations of *M. watsonana*).

Our results suggest that decreased sexual dimorphism in *M. watsonana* from the Zagros populations to the eastern and northeastern populations was understandable and this pattern may be due to environmental changes and hence changes in sexual selection in different habitats. On the other hand, individuals of the Zagros populations have larger heads than the other populations. It may be related to differences in environmental conditions in each region. Ecological causes have been used to explain sexual dimorphism in some lizards (Shine 1989; Schoener 1977). Butler and Losos (2002) explained the relationship between habitat use and extent of sexual dimorphism by two hypotheses:
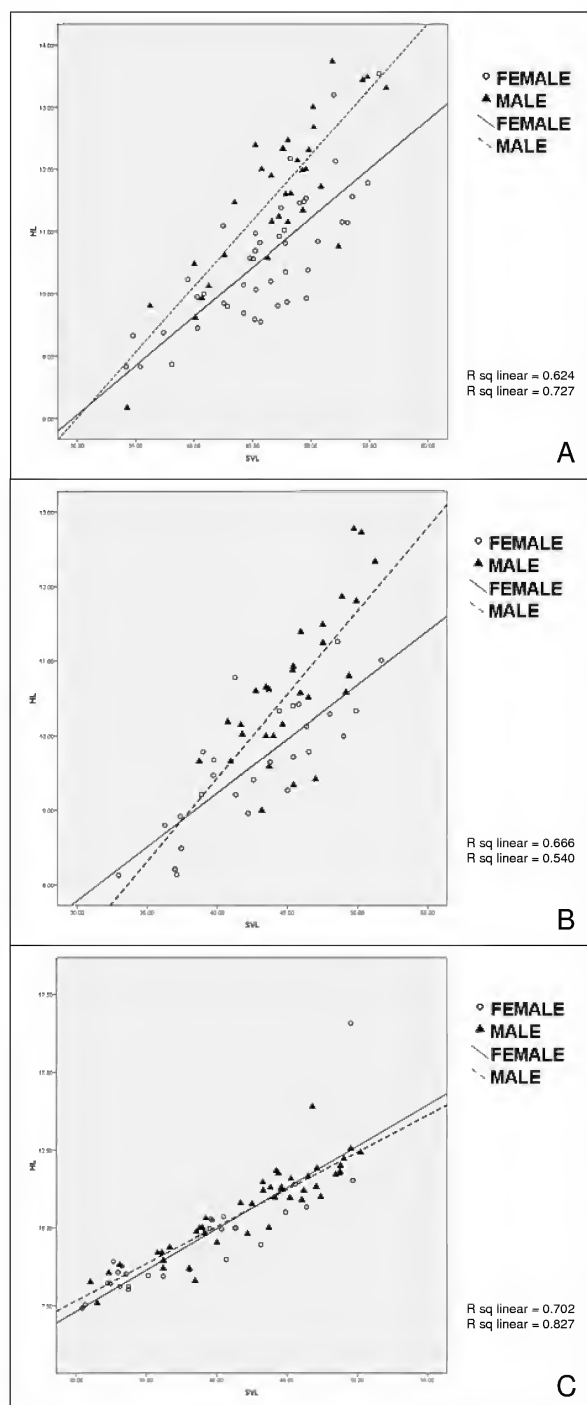
Figure 4. Scatter plots of the head length (HL) against the snout-vent length (SVL) for the Zagros populations (A) Northeastern populations (B) Eastern populations (C) Male = (▲) and Female = (○). Regression lines are shown whenever the slopes are significantly different from zero.

1) Males and females may interact in different ways with the environment, thus leading to a quantitative sex difference in the relationship between morphology and habitat use. This implies that sexes may or may not differ in habitat use, but regardless, the relationship between morphology and ecology will differ between the sexes.

2) The relationship between morphology and habitat use does not differ between the sexes, but the sexes differ in microhabitat use more in some habitats than in others. The amount of ecological difference between the sexes may differ qualitatively among habitats, leading to greater morphological difference in habitats where sexes are more ecologically distinct.

Further, differences in sexual dimorphism between populations of *Mesalina watsonana* may be due to differences in the level of competition experienced by these populations. Sexual dimorphism may be due to other reasons, such as higher survival rates of one sex compared to the other (Vitt 1983), or the differential allocation of energy to reproduction after sexual maturity in males versus females (Cooper and Vitt 1989; Vial and Stewart 1989). It seems that *Mesalina watsonana* feeds on spiders, crickets, beetles, ants and ant larvae and other small insects (Anderson 1999).

The authors in this paper have attempted to explore several aspects of sexual dimorphism patterns in *Mesalina watsonana* in Iran. Key to further understanding entails further field work and behavioral observation especially during the breeding season and the integration of comparative, demographic, and experimental techniques designed to simultaneously address both the ultimate evolutionary causes and proximate developmental mechanisms for sexual dimorphism and unknown aspects of this phenomenon.

Appendix

Material examined (*Mesalina watsonana*)

RUZM, LM 10 / 25-36 (*n* = 11, around Nehbandan, South Khorasan Province, eastern Iran)

RUZM, LM 10 / 37-45 (*n* = 9, Darmian, Asad-Abad, South Khorasan Province, eastern Iran)

RUZM, LM 10 / 46-53 (*n* = 8, around Sarbishe, South Khorasan Province, eastern Iran)

RUZM, LM 10 / 54-59 (*n* = 6, Birjand, Khorashad Village, South Khorasan Province, eastern Iran)

RUZM, LM 10 / 60-65 (*n* = 6, around Khosf, South Khorasan Province, eastern Iran)

RUZM, LM 10 / 66-76 (*n* = 11, Gonabad, Khezri Village, South Khorasan Province, eastern Iran)

RUZM, LM 10 / 77-82 (*n* = 6, around Ferdoos, South Khorasan Province, eastern Iran)

RUZM, LM10 / 83-90 (*n* = 8, Ghaen, Haji-abad Village, South Khorasan Province, eastern Iran)

RUZM, LM 10 / 91-92 (*n* = 2, Khash, Nook-abad, Sistan-Baloochestan Province, southeastern Iran)

RUZM, LM 10 / 93-94 (*n* = 2, Darab, Fars Province, southern Iran)

RUZM, LM 10 / 95-100 (*n* = 6, Fasa, Jellian Village, Fars Province, Southern Iran)

RUZM, LM 10 / 1-24 (*n* = 24, central Iran)

RUZM, LM 10 / 101 (*n* = 1, Masjed Solyman, Golgir Village, Khuzestan Province, southwestern Iran)

ZUTC, REP 1026 (*n* = 10, Biarjmand, Semnan Province, Northern Iran)

ZUTC, REP 1023 (*n* = 1, Khartoran, Kalate Taleb, Semnan Province, northern Iran)

ZUTC, REP 1024 (*n* = 2, around Damghan, Semnan Province, northern Iran)

ZUTC, REP 1025 (*n* = 1, Khartoran, Belbar, Semnan Province, northern Iran)

ZUTC, REP 1027 (*n* = 1, Khartoran, Delbar, Khosh-Chah Village, Semnan Province, northern Iran)

ZUTC, REP 1028 (*n* = 1, Khartoran, Kal e Datjerd Village, Semnan Province, northern Iran)

ZUTC, REP 1079 (*n* = 1, Shiraz, Fars Province, southern Iran)

ZUTC, REP 1332 (*n* = 1, Arak, Delijan, Markazi Province, eastern Iran)

ZUTC, REP 1117 (*n* = 3, Dehdasht,Koh- bord Village, Kohkiloye and Boyer Ahmad Province, southwstern Iran)

ZUTC, REP 1118 (*n* = 3, Arond Dehbasht, Kohkiloye and Boyer Ahmad Province, southwestern Iran)

ZUTC, REP 1119 (*n* = 1, Dehdasht, Ab-Kaseh Village, Kohkiloye and Boyer Ahmad Province, southwestern Iran)

ZUTC, REP 1120 (*n* = 1, Dehdasht, Likak, Kohkiloye and Boyer Ahmad Province, southwestern Iran)

ZUTC, REP 1121(*n* = 3, Dehdasht, Kohkiloye and Boyer Ahmad Province, southwestern Iran)

ZUTC, REP 1122 (*n* = 1, Dehdast, Sogh Village, Kohkiloye and Boyer Ahmad Province, southwestern Iran)

ZUTC, REP 1123 (*n* = 1, Dehdasht, Kohkiloye and Boyer Ahmad Province, southwestern Iran)

ZUTC, REP 1124 (*n* = 1, Dehdasht, Ghal e Madrese Village, Kohkiloye and Boyer Ahmad Province, southwestern Iran)

ZUTC, REP 1175 (*n* = 1, Ghom, Ghom Province, central Iran)

ZUTC, REP 1180 (*n* = 1, Shahr E Babak, Kerman Province, southern Iran)

ZUTC, REP I260 (*n* = 4, Garmsar, Semnan Province, northern Iran)

ZUTC, REP 1334 (*n* = 2, Gheshm Island, Hormozgan Province, southern Iran)

MMTT 1111-1119 (*n* = 9, Bidokht, South Khorasan Province, eastern Iran)

MMTT 1210-1211 (*n* = 2, Soltan Abad, Northern Khorasan Province, northeastern Iran)

MMTT 860-861 (*n* = 2, Khash, Sistan-Baloochestan Province, southeastern Iran)

MMTT 712 (*n* = 1, Khash, Sistan-Baloochestan Province, southeastern Iran)

MMTT 856 (*n* = 1, Khash, Sistan-Baloochestan Province, southeastern Iran)

MMTT 98 (*n* = 1, Khash, Sistan-Baloochestan Province, southeastern Iran)

MMTT 623-624 (*n* = 2, Kerman, Hosein Abad, Kerman Province, central Iran)

MMTT 230 (*n* = 2, Bardesir, Kerman Province, central Iran)

MMTT 1586-1587 (*n* = 2, Kerman, Kerman Province, central Iran)

MMTT 224-226 (*n* = 3, Izeh, Pole Jeh-Jeh, Khuzestan Province, southwestern Iran)

MMTT 1745 (*n* = 1, Izeh, Pole Jeh-Jeh, Khuzestan Province, southwestern Iran)

MMTT 1725-1728 (*n* = 4, Izeh, Mordeh Fill, Khuzestan Province southwestern Iran)

MMTT 2111-2112 (*n* = 2, Izeh, Mordeh Fill, Khuzestan Province, southwestern Iran)

MMTT 2115 (*n* = 1, Izeh, Mordeh Fill, Khuzestan Province, southwestern Iran)

MMTT 1703 (*n* = 1, Izeh, Morde Fill, Khuzestan Province, southwestern Iran)

MMTT 1675 (*n* = 1, Izeh, Morde Fill, Khuzestan Province, southwestern Iran)

MMTT 1716 (*n* = 1, Izeh, Morde Fill, Khuzestan Province, southwstern Iran)

MMTT 251-254 (*n* = 4, Shahrod, Semnan Province, northern Iran)

MMTT 258-262 (*n* = 5, Shahrod, Semnan Province, northern Iran)

MMTT 735-738 (*n* = 4, Sirjan, Kerman Province, southern Iran)

MMTT 785-787 (*n* = 3, Sirjan, Kerman Province, southern Iran)

MMTT 967-969 (*n* = 3, Kashan, Isfahan Provine, central Iran)

MMTT 721 (*n* = 1, Kashan, Isfahan Provine, central Iran)

SUZM 87 (*n* = 1, around Eshghabad, 70 km on the road to Tabas, eastern Iran)

SUZM 116, SUZM 122 (*n* = 2, Deyhook, 5 km on the road to Ferdows, southern Khorasan Province, eastern Iran)

SUZM 252 (*n* = 1, around Mayamai, 60 km E Shahrood, Semnan Province, northeastern Iran)

SMP 200-203 (*n* = 3, Jorbat Village, 35 km E Jajarm, northen Khorasan, northeastern Iran)

SUZM 612, SUZM 614 (*n* = 2, Golgir Village, Khuzestan Province, southwestern Iran)

SUZM 1-2, SUZM 5 (*n* = 3, 25 km E Bardaskan, Khorasan Province, Northeastern Iran)

SUZM 18 (*n* =1, 70 km E Bardaskan, Khorasan Province, northeastern Iran)

SUZM 51, SUZM 53, SUZM 55 (*n* = 3, around Birjand, 10 km on the Sarbisheh, Khorasan Province, eastern Iran)

SUZM 118-119 (*n* = 2, 35 km SW Bam on the road to Jiroft, Kerman Province, southern Iran)

SUZM 69, SUZM 77, RFK 76, RFK 75 (*n* = 4, 20 km E Jajarm, northen Khorasan Province, northeastern Iran)

SUZM 131, SUZM 136 (*n* = 2, 25 km NW Sabzevar, Beed Village, northen Khorasan Province, northeastern Iran)

SUZM 148, SUZM 151 (*n* = 2, 10 km S Sabzevar, Mehrshahi Village, northen Khorasan Province, northeastern Iran)

SUZM 92-93 (*n* = 2, 50 km W Sabzevar, Yosefabad Village, northen Khorasan Province, northeastern Iran)

SUZM 100-101 (*n* = 2, 80 km NW Sabzevar, Kahaneh Village, northen Khorasan Province, northeastern Iran)

SUZM 132 (*n* = 1, 90 km W Sabzevar, around Abasabad, northen Khorasan Province, northeastern Iran)

SUZM 324, SUZM 339 (*n* = 2, around Sabzevar, northen Khorasan Province, northeastern Iran)

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New record of the Western leopard gecko, *Eublepharis angramainyu* Anderson & Leviton, 1966 (Sauria: Eublepharidae) from southeastern Iran

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Abstract.—One adult male specimen of the Western leopard gecko (*Eublepharis angramainyu*) was collected in southeastern Iran during fieldwork conducted from June 2009 to September 2010. The new locality of the species is situated about 600 km east of the type locality. This record indicates a wider distribution of *Eublepharis angramainyu* on the Iranian plateau than previously thought. Information on morphological characters and habitat is presented.

Key words. Western leopard gecko, *Eublepharis angramainyu*, Iran, distribution, color pattern

Introduction

The Leopard gecko, *Eublepharis angramainyu* was originally described from an old road between Masjed-Suleiman and Batwand, Khuzestan Province, Iran by Anderson & Leviton (1966). *E. angramainyu* occurs in western foothills of the Zagros Mountains and in the upper Tigris-Euphrates basin in Iran, Iraq, and northeast Syria. Recently, a new specimen of this species was recorded from southeastern Anatolia and Kara Dagh-Arsanli of Sanliurfa Province, Turkey (Uzum et al. 2008). Grismer (1989) placed *Eublepharis ensafi* Baloutch and Thireau, 1986, in the synonymy of *Eublepharis angramainyu* (Anderson 1999). During field work on the herpetofauna of the southeastern Iranian Plateau from June 2009 to September 2010 one specimen of *Eublepharis angramainyu* was collected from Kerman Province. The new locality of this species is situated about 600 km east of the type locality.

Material and methods

One male specimen of *Eublepharis angramainyu* was collected from Khabr National Park (28°42' N, 56°18' E) in Kerman Province. The specimen was deposited in the Zoological Museum, Shahid Bahonar University of Kerman (ZMSBUK). The specimen was fixed with 96% ethanol, and after 10 days was transferred to 80% ethanol for storage. Morphometric measurements were taken by

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calipers to the nearest 0.1 mm, and meristic characters were recorded by stereomicroscope in the Zoological Lab of the University of Kerman.

Results

Pholidosis

Supranasal scales separated by single internasal scales; 40-41 eyelid fringe scales; 11 supralabials; 11-12 infralabials; chin shield in contact with first lower labials; 10-12 smaller scales surround each dorsal tubercle; hexagonal ventral scales in 25 longitudinal rows; 7 discernible precloacal pores; 24 smooth subdigital lamellae; three transverse rows of ventral scales in each caudal whorl; dorsal scales of regenerated tail circular and slightly convex.

Color pattern

Dorsum dark lemon-yellow with a continuous light vertebral stripe, bordered on each side by a broken black stripe from occiput to base of tail; dorsum with dark longitudinal stripes arranged in six rows, some complete and others broken; head with a pattern of dark and light reticulations; limbs light lemon-yellow with numerous dark spots; tail whitish with numerous irregular dark transverse marks; and venter light tan (Fig. 1).

Figure 1. *Eublepharis angramainyu.*

Measurements

SVL (snout-vent length): 140 mm; HL (head length): 34.79 mm; HH (height of head: from top of head to the lower base of jaw): 19.34 mm; HW (width of head: from widest part): 28.41 mm; INTNOST (internostril distance): 5.52 mm; EYENOST (distance between anterior edge of eye to nostril): 11.31 mm; NOSTIP (distance between anterior edge of the nostril to the tip of snout; TED (transverse eye diameter): 10.11 mm; Thigh length: 28.38 mm; Crus length: 28.04 mm; Arm length: 22.05 mm; Forearm length: 22.05 mm.

Habitat

The specimen was found in rocky desert and arid grasslands, two hours after sunset, when air temperature was 29 °C. The specimen was observed at 1868 m above sea level (asl). The vegetation at the site is dominated by *Artemisia* sp., *Amygdalus scoparia*, *Cousinia stocksii*, and *Ebenus stellata* (Fig. 2).

Discussion

The range of *Eublepharis angramainyu* is the western foothills of the Zagros Mountains and northern Mesopotamian Plain in Iran and Iraq (Szczerbak and Golubev 1996; Anderson 1999) connecting Afrotropical and Palaeractic elements of the herpetofauna in the eastern Mediterranean (Disi and Böhme 1996). This record indicates a wider distribution of *Eublepharis angramainyu* in Iran than previously thought (Fig. 3).

In pholidosis and coloration, the Khabr specimen agrees in general with the descriptions of *Eublepharis angramainyu* given by Anderson and Leviton (1966), Leviton et al. (1992), Göçmen (2002), Szczerbak and Golubev (1995), and Anderson (1999), except for the eyelid fringe scale count (40-41 instead of 41-48) and ventral scales at midbody (25 instead of 27-38). In comparison with *E. angramainyu*, *E. macularius* has 46-57 eyelid fringe scales and subdigital lamellae each with several distinct small tubercles. The range of *E. macularius* is in eastern Afghanistan, Pakistan, Khandesh District of India, and possibly eastern Iran.

Figure 2. Habitat of *Eublepharis angramainyu.*

Western specimens seen in the wild were found in rocky deserts and arid grasslands. They occur in the small caverns in the gypsum deposits (Karamiani et al. 2010). The habitats are similar despite the wide distances between localities except for elevational range (1868 m instead of 300-1427 m).

The new locality of the species is situated about 600 km east of the type locality, therefore this specimen may represent a cryptic species and require a population study.

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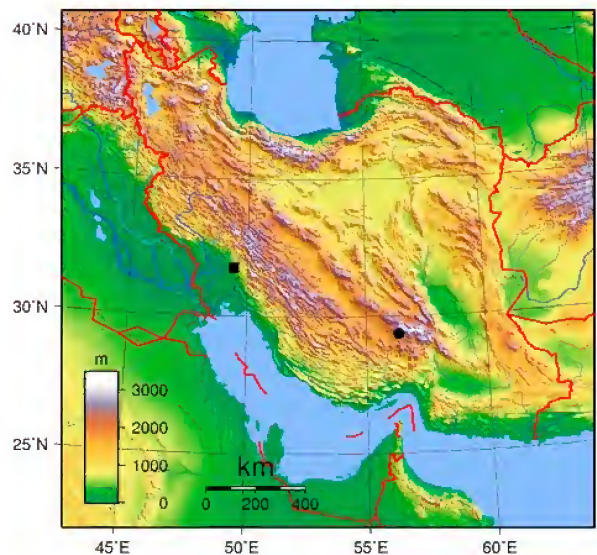
Figure 3. *Eublepharis angramainyu* type locality, square (Anderson and Leviton 1966), new locality, circle.

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Sexual size dimorphism in *Rana* (*Pelophylax*) *ridibunda ridibunda* Pallas, 1771 from a population in Darre-Shahr Township, Ilam Province, western Iran

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Abstract.—In this survey we investigated occurrence of sexual size dimorphism (SSD), in a population of *Rana* (*Pelophylax*) *ridibunda ridibunda* Pallas, 1771 from Darre-Shahr Township, Ilam Province, western Iran. Ninety-six specimens (52 females and 44 males) were captured, measured and released into their natural habitat. Twelve metric characters were measured by digital calipers to the nearest 0.01 mm. Statistical analyses showed considerable differences between sexes for measured characters. The largest female and male were 89.55 and 73.16 mm SVL, respectively, while the smallest female and male were 68.52 and 61.65 mm SVL, respectively. SPSS version 16 was used for running the analysis. The Independent-Sample *t*-test (2-tailed) showed that each character has significant differences between the sexes ($p \leq 0.01$), and for each variable the female value was larger than for males on average.

Key words. Sexual size dimorphism (SSD), *Rana* (*Pelophylax*) *ridibunda ridibunda*, Principal Component Analysis (PCA), Ilam Province, western Iran

Introduction

Sexual dimorphism refers to the existence of phenotypic differences between males and females of a species, and is widespread in animals (Andersson 1994; Faizi et al. 2010). Kuo et al. (2009) considers the presence of morphological differences between males and females of species to have two aspects, size and shape, but Selander (1972) credits behavioral aspects as well. Different factors can influence sexual dimorphism including female reproductive strategy (Tinkle et al. 1970; Verrastro 2004), sexual selection (Carothers 1984; Verrastro 2004), and competition for food resources (Schoener 1967; Verrastro 2004). Sexual size dimorphism (SSD) is a common and widespread phenomenon in animal taxa, but highly variable in magnitude and direction (Andersson 1994; Fairbairn 1997; Brandt and Andrade 2007). Sexually dimorphic traits have been surveyed in different classes of vertebrates, including birds (Selander 1966, 1972; Temeles 1985; Temeles et al. 2000), primates (Crook 1972), amphibians (Shine 1979; Woolbright 1983; Monnet and Cherry 2002; Schäuble 2004; Vargas-Salinas 2006; McGarrity and Johnson 2008), lizards (Stamps 1983; Rocha 1996; Carothers 1984; Trivers 1976; Molina-Borja 2003; Baird et al. 2003; Verrastro

2004; Bruner et al. 2005; Kaliontzopoulou et al. 2007), and snakes (Shine 1978, 1993, 1994; Feriche et al. 1993; Kminiak and Kaluz 1983; Shine et al. 1999).

To our knowledge, such a survey has not yet been documented for the Marsh frog, *Rana ridibunda ridibunda* in Iran. The Marsh frog, *Rana* (*Pelophylax*) *ridibunda ridibunda* Pallas, 1771, has a relatively wide distribution throughout Iran, except for southeastern regions (i.e., Sistan and Baluchistan Province; Baloutch and Kami 1995). We analyzed sexual size dimorphism in this species to reveal sexually dimorphic traits that can be important in systematic and evolutionary research.

Materials and methods

The current survey was carried out about five km from Darre-Shahr city, Ilam province, western Iran (Fig. 1), 33°11′ N and 47°22′ E, 620 m above sea level (asl) and with 486 millimeter (mm) annual precipitation. All 96 specimens (52 ♀ and 44 ♂) were collected using a handmade butterfly net in streams, brooks, and cultivation waterways. Twelve morphometric characters were chosen and measured by a digital caliper to the nearest 0.01

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mm and are presented in Table 1. Morphometric varible measurements were obtained from as many specimens as possible per locality and released unharmed at the original capture location. The same procedure was repeated in localities separated as far as possible to ensure that none of the individuals were counted twice. Two distinctive characters were used to distinguish males from females: first, the vocal pouches at the ends of buccal slits, just under the tympana at the sides of head and second, the digital pads on thumbs (Fig. 2). To test significance of sexually dimorphic characters, Independent Sample t-test (2-tailed) as well as Principal Component Analysis (PCA: correlation matrix) at the significance level of 0.01 were employed. SPSS software version 16 was used for running the statistical analyses.

Results

Independent-Samples *t*-test (2-tailed)

The results of the Independent-Samples t-test (2-tailed) show all variables differed significantly between sexes ($p \leq 0.01$), with each variable being greater in females than males (Table 2).

Principal Component Analysis (PCA)

The two axes of the PCA explain 82.08% of the total variation. The Principal Component One (PC1) accounts for 73.95% and the Principal Component Two (PC2) for 8.13% of the total variation (Table 3). For PC1, the variables SVL, LHL, LFL, FHL, HL, HW, NNL, TL, and L4T (see Table 1 for the morphometric characters used in the study) are the most sexually dimorphic characters. All these variables have the same direction (positive = larger females) but not the same magnitude (Fig. 3). The values of the females along PC1 do overlap, to some extent, with those for males, indicating that the sexes are
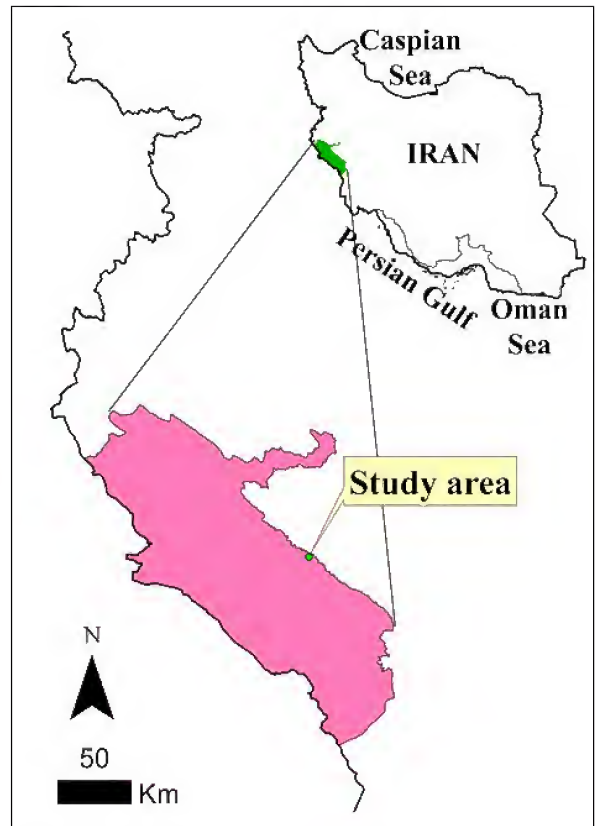
Figure 1. Map showing the study area in Ilam province, western Iran.

not fully separated from each other. The first axis is a reflection of size with about 45% of males and 23% of females inseparable in these characters. The PC2 on the other hand shows almost no discrimination between the sexes, explaining only 8.13% of the total variation in which the characters EEL and ELW having the most important role (Fig. 3, Table 3).

Conclusion

There is an accepted hypothesis that explains the status and direction of sexual size dimorphism in anurans, where males are usually smaller than females as a result of sexual selection (Monnet and Cherry 2002). In 90% of the anuran species, the females are larger than males (Shine 1979). As is obvious from Table 2, each character tested for *Rana r. ridibunda* was significantly ($p \leq 0.01$) different for males and females on average and 100% of the measured characters are indicative of the presence of sexual dimorphism in size.

In some species of frogs, males are much smaller than females and it is not necessary to carry out statistical analyses (Hayek and Heyer 2005). But for *R. r. ridibunda* it was not completely clear that males are smaller than females without the help of statistical analyses. Shine (1979) showed that in species exhibiting male combat, males are often larger than females, but in our analyses

Table 1. The morphometric characters used in this study.

Characters	Definition
SVL	Snout to vent length
LHL	Length of hindlimb
LFL	Length of forelimb
FHL	Forelimb to hindlimb length
HL	Head length
HW	Head width
EEL	Eyelid to eyelid length
SEL	Snout to eye length
ELW	Eyelid width
NND	Distance between nostrils
TL	Tympanum length
L4T	Length of the 4th toe

Table 2. Comparison of morphometric characters (mm) in males and females of *Rana ridibunda ridibunda*. *n*: number; SEM: standard error of mean; * = significant at level 0.01. Morphometric abbreviations: SVL (snout-vent length), LHL (length of hindlimb), LFL (length of forelimb), FHL (forelimb to hindlimb length), HL (head length), HW (head width), EEL (eyelid to eyelid length), SEL (snout to eye length), ELW (eyelid width), NND (distance between nostrils), TL (tympanum length), L4T (length of the 4th toe).

SEX		SVL*	LHL*	LFL*	FHL*	HL*	HW*	EEL*	SEL*	ELW*	NNL*	TL*	L4T*
♂	mean	67.16	103.33	36.27	30.36	18.80	23.12	3.33	10.50	4.82	3.97	4.74	18.54
(*n* = 44)	SEM	0.48	0.70	0.25	0.32	0.16	0.18	0.05	0.09	0.09	0.04	0.05	0.14
♀	mean	78.36	120.14	41.12	36.04	21.71	26.52	3.94	12.29	5.19	4.47	5.45	21.13
(*n* = 52)	SEM	0.78	1.01	0.37	0.43	0.24	0.31	0.07	0.22	0.07	0.05	0.06	0.17
p-value (≤ 0.001)		0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000
Difference between means		11.2	16.81	4.85	5.68	2.91	3.4	0.61	1.79	0.37	0.5	0.71	2.59

here, all measured characters in Table 2, size of female characters are significantly larger than males. According to Shine (1979), in most cases the causes of sexual dimorphism in frogs are not known and also in *R. r. ridibunda* the actual causes of this high degree of sexual dimorphism in our data are not fully understood. Given this, it seems that there is an outstanding problem in statistical significance versus biological significance when evaluating sexual dimorphism in measured characters of *R. r. ridibunda*. Regardless of any evolutionary or ecological causes of observed sexual dimorphism in *Rana r. ridibunda*, with respect to the three usual and accepted hypotheses of sexual size dimorphism in all animals: (1) fecundity selection on female body size (Wiklund and Karlsson 1988; Fairbairn and Shine 1993), (2) sexual selection on male body size (Cox et al 2003), and (3) ecological divergence between sexes due to intraspecific competition (Butler et al. 2000; Bolnick and Doebeli 2003); there is an uncertainty in clarifying the main force(s) causing a high degree of sexual size dimorphism in this species. More profound surveys are needed to uncover the main cause(s) of SSD in *R. r. ridibunda*.
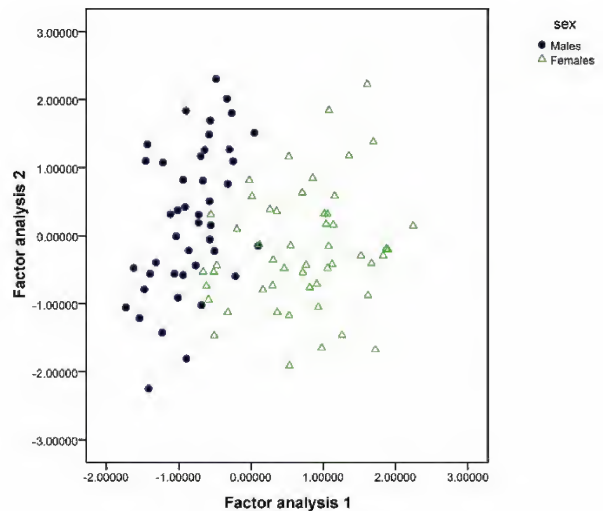
Figure 3. Ordination of the individual males and females of *Rana* (*Pelophylax*) *ridibunda ridibunda* on the first two principal components. Note the relative degree of isolation between males and females, which is mainly attributed to SVL, LHL, LFL, HL, and HW in the PC1 and EEL and ELW in the PC2.
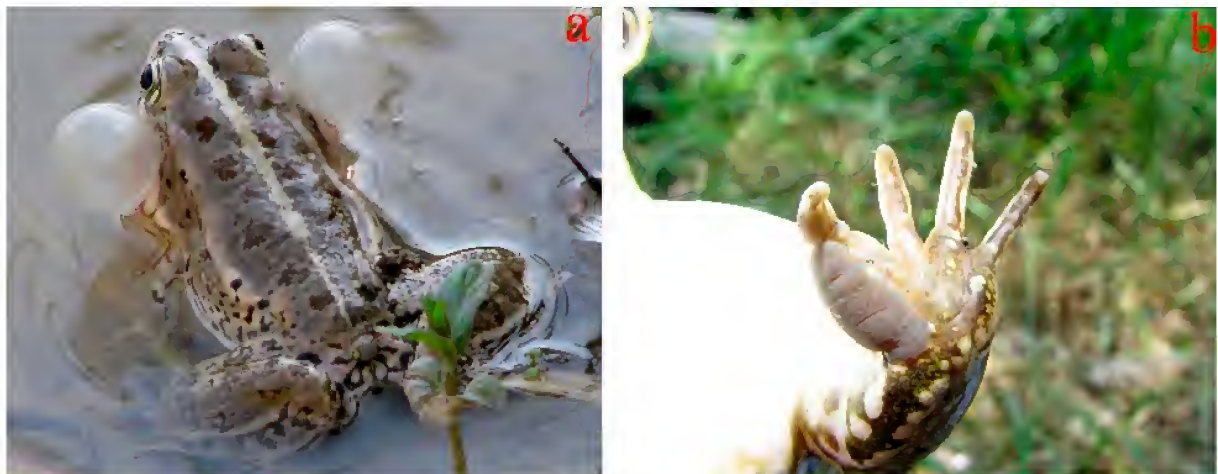
Figure 2. The presence of vocal pouches (a) and digital pads (b) in male *Rana* (*Pelophylax*) *ridibunda ridibunda* distinguishes them from females.

Table 3. Extraction of Principal Components 1-3 using the component matrix. Variables loading strongly on each principal component are bold. Abbreviations: SVL (snout-vent length), LHL (length of hindlimb), LFL (length of forelimb), FHL (forelimb to hindlimb length), HL (head length), HW (head width), EEL (eyelid to eyelid length), SEL (snout to eye length), ELW (eyelid width), NND (distance between nostrils), TL (tympanum length), T4T (length of the 4th toe).

Variables	PC 1	PC 2	PC 3
SVL	**0.964**	0.002	0.041
LHL	**0.941**	-0.164	-0.124
LFL	**0.900**	-0.230	-0.121
FHL	0.877	-0.134	0.069
HL	**0.953**	0.145	0.068
HW	**0.951**	-0.087	0.042
EEL	0.678	**-0.540**	**0.311**
SEL	0.766	0.128	**-0.431**
ELW	0.669	**0.660**	0.106
NNL	0.848	0.105	**0.311**
TL	0.866	0.210	0.037
L4T	0.841	-0.225	-0.269
Eigenvalue	8.857	0.976	0.507
% variation explained	73.956	8.130	4.225

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Notes on reproduction and conservation of *Testudo graeca ibera* Pallas 1814 (Reptilia: Testudinidae) in Zagros, western Iran

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Abstract.—During longtime fieldwork in the Zagros Mountains, we studied tortoises of the western Iranian plateau. In this paper we focus on *Testudo graeca ibera*. We present the first information about mating behavior, timing of mating, egg shape, and hatching of this subspecies. In general, our results on reproduction in *T. g. ibera* are different from previous reports. Additionally, we report anomalous reproductive behavior in *T. g. ibera*.

Key words. *Testudo graeca ibera*, mating, eggs, Zagros Mountains, Iran

Introduction

Testudo graeca includes two subspecies on the Iranian plateau: *T. g. ibera*, distributed in western Iran, and *T. g. zarudnyi*, distributed on the eastern Iranian Plateau (Anderson 1979; Torki 2010). We realize that the nomenclature of southwest Asian tortoises is in flux, as there seems not to be a recognized consensus as yet; here we use the conventional taxonomy of the older literature.

Jasser-Hager and Winter (2007) reported results regarding incubation in tortoises, including a Greek population of *T. g. ibera*. Information on reproduction of this species in Iran is very rare (Pritchard 1966). In this paper we focus on husbandry of *T. g. ibera* on the western slope of the central Zagros Mountains, western Iranian plateau.

Materials and methods

To study reproduction in *T. g. ibera*, we worked in the natural habitat from 2002-2010 in this region. After egg deposition by one female specimen under natural conditions, we transferred all eggs into our lab. Thus, our results are based on our observations under natural and laboratory conditions.

Results and discussion

Mating activity time

Mating of *T. g. ibera* in the Zagros population occurred from early spring to late summer. Pritchard (1966) observed copulation in the Zagros population of *T. graeca*

in late August and early September, whereas Nikolsky (1915) recorded mating in April and May in the Transcaucasian area. Mating behavior for *T. g. ibera* in Greece was observed during two time periods: March-April and late autumn (Jasser-Hager and Winter 2007). In contrast, we did not see any tortoises in natural habitats in the central Zagros Mountains during mid- and late autumn. Temperatures during this time are low and most species of herpetofauna are going into hibernation (e.g., Torki 2007a, b). Thus, there is a difference in timing of mating and courtship between the Zagros and Greek populations of *T. g. ibera*.

Most mating occurred in shady places, such as under trees or other vegetation, large stones, etc. Jasser-Hager and Winter (2007) reported maximum mating of *T. g. ibera* in Greece during morning hours. Maximum mating in the Zagros populations mostly occurred near mid-day, from 11:00 to 15:00. Mating in *T. g. ibera* usually occurred after feeding.

Mating behavior

Based on our observations (from 2002-2010) of 35 pairs (female: 35; male: 35) of *T. graeca*, we classified courtship behavior into four phases as follows:

1. *Aggressive phase*: aggression is the first step in courtship; in this step, the male attacks the rear of female's carapace and females attempt to escape during this phase. In our observations, this behavior occurred repeatedly several times. The duration of this phase differed among specimens; in general, duration was between 10 and 50 minutes. Biting occurred during this phase; the male bit the limbs, neck, or head of the female. Duration of the aggressive phase was related to (a) agility of male, as agile males were successful with a decreased aggres-

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sive phase; and (b) place of mating, as minimum duration occurred in uneven terrain (such as in mountains) and maximum duration occurred in flatter terrain (such as agricultural land).

2. *Submission phase*: after the aggressive phase, the female remains in one place and the male can start the mating step. The duration of this phase was related to the terrain; in even places, the duration of this step was less than in uneven terrain, as the male has to rest for a few minutes on rougher ground.

3. *Copulation phase*: copulation occurred between 5 and 21 times for each pair. The rate of coupling was related to duration of the first phase, which may reduce energy of the male for mating. The duration of each copulation was between approximately 10 and 70 seconds. The duration of this time was in inverse relationship to the duration of the aggressive phase; if the duration of the aggressive phase was short, then duration of the mating step was longer (because males have maximal energy for mating); in contrast, if duration of the aggressive step phase was longer, then duration of the mating step was short (presumably because males were tired due to running and did not have sufficient energy for as many copulations).

4. *Resting*: the resting step occurred in most specimens, because both sexes, especially males, expend much energy for successful mating. After mating, the male and female rest close together. The duration of the

resting time is related to duration of mating; duration of the resting step was minimal when mating occurred in the morning and maximal when mating occurred in the afternoon, possibly because individuals must sleep, or perhaps because afternoon temperatures are higher.

Douglas et al. (1994) reported courtship behavior in the Desert tortoise (*Gopherus agassizii*) and described several phases for courtship behavior: *trailing*, *biting*, *rear ram*, *soliciting*, *mount*. These phases occurred for *T. graeca* and the aggressive phase in this study is the same as the *trailing*, *biting*, *rear ram*, and *soliciting* phases of Douglas et al. (1994). Douglas et al. (1994) reported the final step of courtship behavior as follows: mount by male while female does head-swing. Head-swing of female occurred in *T. graeca* during the copulation phase. In this study we reported a resting phase; also, this phase is outside of mating behavior, but we cite this phase in mating (or courtship) behavior because, the resting phase occurred as the result of all previous phases of this study. We see this phase in other reptiles, such as *Lacerta media* and *Laudakia nupta*.

Anomalous mating behavior

Both in captivity and in the natural habitat, we saw several unsuccessful mating or courtship attempts in *T. graeca*: (a) Unsuccessful mating: males sometimes directed mating behavior toward an inappropriate part of the fe-

Figure 1. Mating of *Testudo graeca ibera*, Zagros populations. *Photo by Farhang Torki.*

male body, such as dorsolateral or anterior of females. (b) Anomaly: male specimen attempted to mate with other animals (not females of *T. graeca*), for example, under captive conditions, a male *T. graeca* attacked and repeatedly showed mating behaviors toward *Mauremys caspica*. (c) Male-male courtship and mating: under captive condition some male specimens showed courtship and mating behaviors with other males.

In general, mating anomalies occurred only in male specimens. Therefore, in this study we report anomalous mating behavior in *T. graeca* for the reason that males of *T. graeca* showed courtship and mating behavior toward other animals, materials, etc. (e.g., inappropriate parts of female body). We observed maximum anomalous behavior under captive conditions.

Hatching

During our fieldwork in the Zagros Mountains, we observed one female during egg laying. Egg laying occurred on 13 May 2010 at 1630 h in even terrain. The female excavated a nest cavity during less than 10 minutes. She laid four eggs (Fig. 3) during ten minutes, and covered the eggs in five minutes. The nest cavity is shown schematically in Fig. 4. Egg shape was oval (Fig. 3) as is true for most tortoises, such as other subspecies of *Testudo graeca* and *Indotestudo forstenii* (Kruger 2007; Jasser-Hager and Winter 2007; Struijk 2009). Hiley and Loumbourdis (1988) reported egg size, shape, and weight of *Testudo graeca* from northern Greece (Table 2). Our comparison with this population showed that eggs of the Iranian *T. graeca* population have greater length, width, and especially, mass. Jasser-Hager and Winter (2007) reported that eggs average 25 g (range 14-33 g) for a northern Greek population. Both reports about egg weight of *T. graeca ibera* in Greece record less weight than in the Zagros population.

We transferred eggs from natural habitat to laboratory conditions. We preserved one egg and provided a nest cavity for the other eggs. We inserted the three eggs into the cavity and covered them with soil. No further care of the eggs was provided. We only covered eggs with soil (similar to natural conditions; see Fig. 4). All environmental conditions of the laboratory were similar to those of the natural habitat. We did not touch the eggs, because handling stops egg development, as our experiments with other reptiles had confirmed. Therefore, we transferred all eggs using paper or wood. Duration of incubation of eggs varied from 72 to 76 days (Tab. 1; Fig. 5). In comparison, Jasser-Hager and Winter (2007) reported the incubation period for *Testudo graeca* in Greece as between 54 and 89 days (average 62 days), for *T. hermanni* boettgeri between 49 and 72 days (average 56 days), and for *T. horsfieldii* between 54 and 102 days (average 68 days).

We preserved one egg the first day and measured thickness of the shell. We recorded shell thickness for other eggs after hatching. Our results show that the egg shell has a maximum thickness during the first day after laying (middle of egg: 0.25 mm) and has minimum thickness at hatching (middle of other eggs: 0.12, 0.10, and 0.07 mm). Decreased shell thickness is probably important for easy hatching and/or drawing essential elements from the shell. After egg-laying, the egg shell was soft and flexible; this is in contrast to the following days, especially at hatching. During this time, egg shells were stiff and breakable.

Juvenile specimens have a circular shape, with carapace length and width and plastron length and width being similar (Table 1). This is true for other tortoises, es-

Figure 2. Anomalous mating behavior of *Testudo graeca ibera*. (a) Mating behavior of *T. g. ibera* with *Mauremys caspica*; (b) Mating behavior of *T. g. ibera* with anterior body of other specimen; (c) Mating behavior of male *T. g. ibera* with another male. *Photos by Farhang Torki.*

Table 1. Measurements and information on four eggs of *Testudo graeca ibera* after egg-laying (13 May 2010) and after hatching (24-27 July 2010). The third egg did not hatch.

Measurements	1st egg	2nd egg	3rd egg	4th egg
Length (mm)	45.9	45.1	44.9	43.4
Width (mm)	33.8	34.4	34.9	31.6
Weight (g)	28	28	30	26
Hatching date	24 Jul 10	25 Jul 10	-	27 Jul 10
Time of day	sunset	afternoon	-	sunset
Carapace length	40.8	35.8	-	35.7
Carapace width	37.1	35.2	-	34.8
Plastron length	34.9	32.1	-	31.6
Plastron width	33.2	31.1	-	30.7

Figure 3. (a) Four eggs of *Testudo graeca ibera*, after oviposition, (b) One egg of *T. g. ibera*, under captive conditions. *Photos by Farhang Torki.*

pecially for other subspecies of *Testudo graeca* (Kruger 2007; Jasser-Hager and Winter 2007). Plastrons of hatchling specimens were covered by yolk sacs. After hatching, the yolk sac was distinct from plastron of juveniles (Fig. 6). The bodies of juveniles during the first days after hatching are soft. The plastron and especially the carapace of juveniles harden after more than one month.

Conservation

Several factors pose threats to *T. graeca* in the Zagros Mountains; we classified these factors as follows.

Natural threats

(a) Drought indirectly and directly affected survival of *T. graeca*, especially juvenile specimens. (1) *Directly*: physical activity of *T. graeca* was reduced during high temperature, especially during mid-day (especially in summer). Temperature during recent years has increased (IMO). Therefore, daily biological activity of *T. graeca* was reduced. This is true for juvenile specimens. Juvenile specimens must obtain more food. Hence, during high temperatures, physical activity of juvenile specimens is strongly reduced. Therefore, some juvenile specimens are not successful in obtaining food and survival of juveniles is endangered due to drought. (2) *Indirectly*: Drought occurred during several recent years. Density and longevity of vegetation during droughts is reduced (our observation). Therefore, the rate of food production is reduced during the warm season (summer). Juvenile specimens could not obtain enough food. Some adults and juvenile specimens could not store enough fat for hibernation periods; this occurred due to loss of food in natural habitats.

(b) *Predators*: based on our observations and life history of *T. graeca*, we divided predators of *T. graeca* into three types, as follows: (a) egg predators, including some snakes (*Eryx*) and scincid lizards; (b) predators of young, including birds (crows, ravens, etc.), and mammals (some carnivores; Fig. 7c); (c) and predators of adult *T. graeca*, such as birds (eagles) and mammals (some carnivores). Eagles grab adults and fly to high altitudes (more than
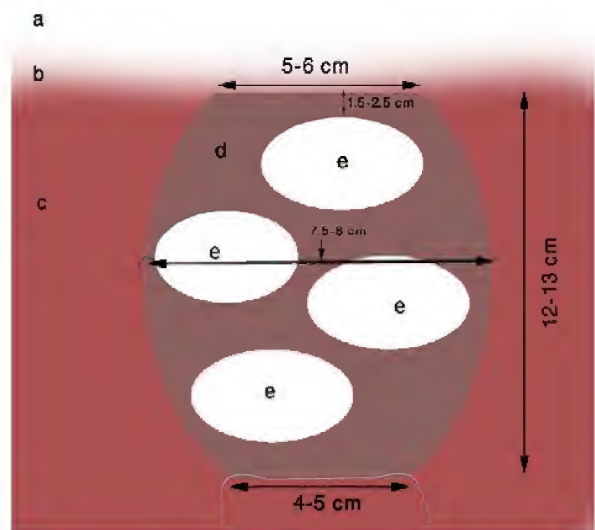
Figure 4. Schematic of egg-site in *Testudo graeca ibera*, Zagros Mountains. Abbreviation: a: air; b: surface; c: soil; d: hollow egg-site; e: eggs.

Table 2. Egg size and weight comparison of northern *Testudo graeca ibera* between two populations: western Iran (Zagros) and northern Greece.

	Hiley and Loumbourdis 1988	Present study	Population fitness: Iran and Greece
Year assessment	1985-1986	2010	
Location	northern Greece	western Iran (Zagros)	
Weight (g)	17.5 ± 2.0	28 ± 0.80	1.6
Length (mm)	35.4 ± 2.0	44.8 ± 0.50	1.2
Width (mm)	29.2 ± 1.9	33.68 ± 0.7	1.1
Shape	1.22 ± 0.1	1.32 ± 0.02	1.1
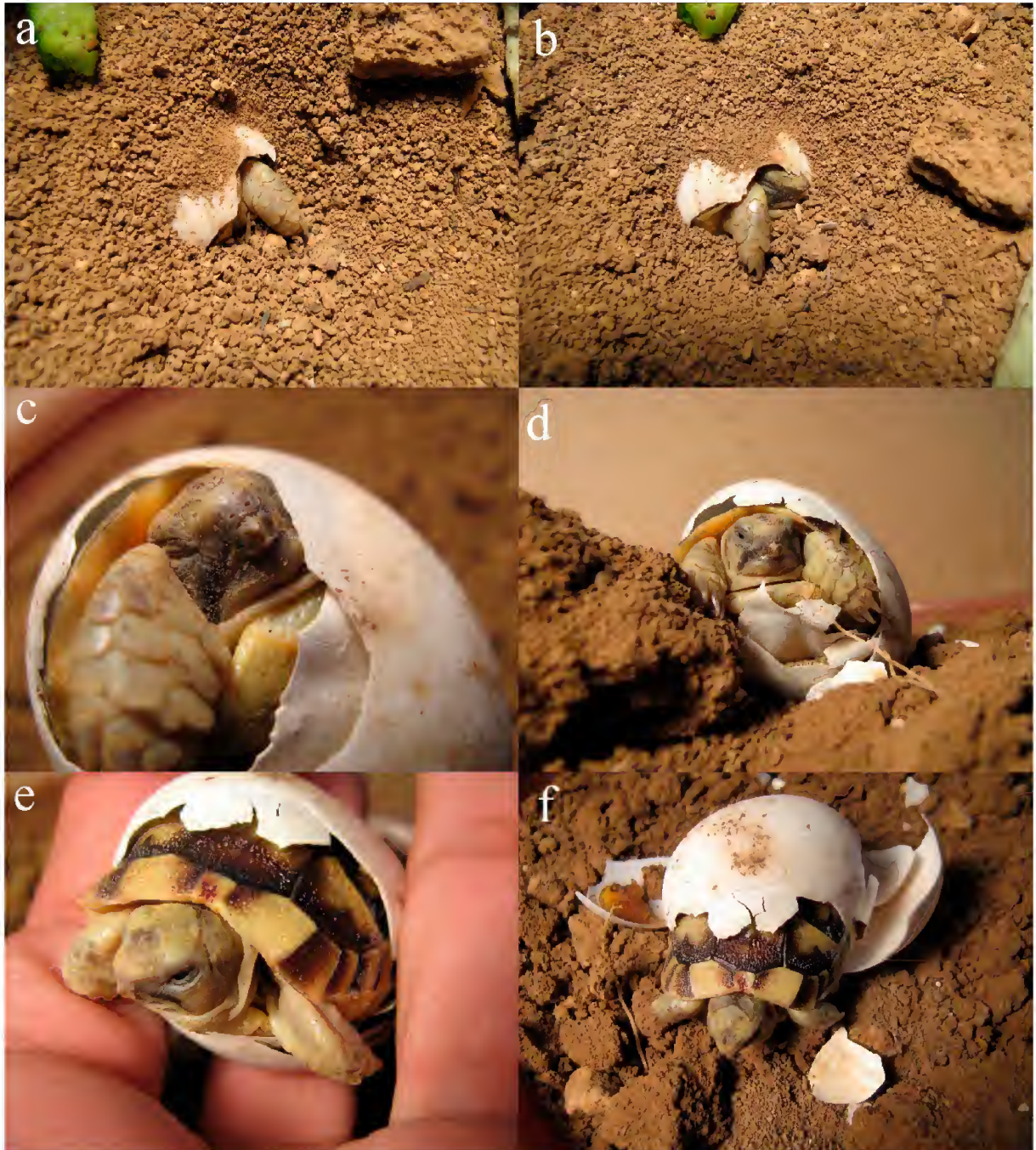
Figure 5. Hatching of *Testudo graeca ibera*. a-f: arrangement of broken egg shell (during hatching). *Photos by Farhang Torki.*
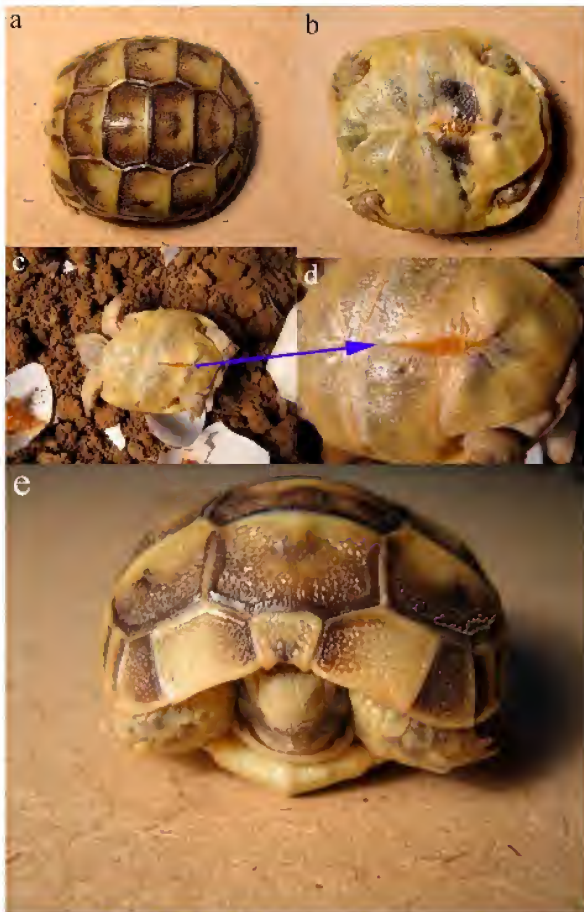
Figure 6. Hatchling specimens of *Testudo graeca ibera* under captive conditions. (a-b) carapace and plastron of juvenile specimens (after one week); (c-d) plastron of juvenile specimens (one day old), showing narrow yolk sac; (e) juvenile specimens after one month. *Photos by Farhang Torki.*

100 m) and release them. Due to this action, the shell of T. *graeca* is broken and eagles easily eat adults. Several predators such as birds, dogs, and wolves eat T. *graeca*; this occurs due to loss of food in the natural habitat.

(c) *Ectoparasites*: the main ectoparasites of T. *graeca* in this region are several taxa of Acari (*Acarina*, ticks; Fig. 7d). Ticks attach to carapace, plastron, and limbs. We see most ticks on soft parts, such as joints of scutes or limbs.

Human threats

(a) *Habitat destruction*: habitat destruction occurs due to several important factors. (1) *Ashayer* (nomadic herders): the lifestyle of some peoples in the Zagros Mountains is similar to that of other herders elsewhere; they do not build homes, but live together in nature. Ashayer, for migratory periods of their lives, only use natural material; for example: they cut trees for fire. Ashayer and their animals, such as goats, are in competition with most wild animals, such as T. *graeca*, for food resources. (2) *Building roads*: many animals are killed on roads during day

and night. We could see several corpses of T. *graeca* on roads or near roads (Fig. 7b). All specimens were killed due to various vehicles. Based on our observation on one road in northern Lorestan Province, more than 20 corpses of T. *graeca* were seen on roads or near roads; all specimens were killed by vehicles. (3) *Recreation*: some areas are good places for recreation. People play a negative role during recreation, for example, some people bring juvenile specimens of T. *graeca* home and some people release their trash and other waste into the environment. Some wastes, such as oils and grease, are released into the natural habitat of T. *graeca*. These materials have a negative role in the survival and life of T. *graeca*, especially juveniles.

(b) *People's beliefs* (outlandish stories): this factor occurred during past years in the Zagros Mountains, but we could not see or hear any reports about this threat in recent years. Mostly people killed turtles for some purposes, such as to make love potions, increased milk production of cows, etc. These are ancestral beliefs, and today no one pays attention to these outlandish stories.

(c) *Agriculture*: (1) destruction of eggs and juvenile specimens by agricultural elements during planting and harvest; (2) killing tortoises by plough (agriculture elements); (3) chemical materials; these are important threats to most animals, because most farmers use chemical materials for their farmland. In some cases some farmers release the runoff of chemical materials out of their farmland into the habitat. Poison is distributed to nature and T. *graeca* (and other animals) are affected directly or indirectly by these poisons. (d) Fire (Fig. 7a): During recent years, human-caused fire has occurred in the central Zagros Mountains. Due to fire, the habitat of T. *graeca* and other animals is damaged. In some cases we could see corpses of some animals such as T. *graeca*, killed due to fire. Most fires occur after harvest; this time is synchronous with hatching of most reptiles, such as T. *graeca*. In addition, due to fire, juvenile reptiles cannot obtain an abundance of necessary fat. Therefore, these specimens cannot live through their hibernation period (and die in mid-hibernation).

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Figure 7. Natural (a, b) and human (b, c) threat factors in *Testudo graeca ibera*. (a) Fire: human-caused fire in natural habitat of *T. g. ibera* and agriculture land; (b) Building roads: one specimen killed on road by cars; (c) Predators: one specimen killed by birds; (d) Exoparasites: one species of Acari on plastron of *T. g. ibera*. *Photos by Farhang Torki.*

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Book Review of The Wildlife Techniques Manual

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The 7th edition of *The Wildlife Techniques Manual* is a landmark publication that will certainly become a classic and highly recommended tool (Figure 1). The 7th edition is completely revised and updated, and for the first time appears as a two-volume set. Volume 1, with 22 chapters, covers techniques in wildlife research, and Volume 2, with 15 chapters, covers techniques in wildlife management (see the appendix for a complete list of chapters).

Since its original publication in 1960, *The Wildlife Techniques Manual*, a concept created by The Wildlife Society, has remained the cornerstone text for the professional wildlife biologist. Every decade or so (Figure 2) the book is revised, edited, and updated. As new techniques are developed, new chapters are warranted. Edited by Nova J. Silvy, the new edition covers new methodologies used in the field and laboratory. Topics include experimental design, wildlife health and disease, capture techniques, population estimation, telemetry, vegetation analysis, conservation genetics, wildlife damage management, and urban wildlife management.

As I read through the manual, one chapter in particular caught my attention: Chapter 5, use of dogs in wildlife research and management (Dahlgren 2012). I have a keen interest in the use of dogs in conservation because I worked with a dog handler in the early 2000s searching for the often elusive San Joaquin kit fox (*Vulpes macrotis mutica*; Smith et al. 2006). My dog handler colleague, Dr. Deborah A. Smith, was indeed a co-author on this chapter and I was very pleased to see her work mentioned in this manual. Certainly, the use of dogs in wildlife studies is a new thing? In assuming this, I am wrong. The 4th edition was the first to have a chapter specifically on the use of dogs in wildlife biology (Zwickel 1980). However, a chapter specific to dogs as wildlife management tools did not appear again until the 7th edition. The ebb and flow of chapter topics represents how the wildlife research community perceives demand for various field techniques and methods.

Chapter 6 is an important example of how relevant *The Wildlife Techniques Manual* is to current events (Sheffield 2012). At 9:45 PM, CDT, on 20 April 2010, the Deepwater Horizon offshore oil drilling rig exploded and resulted in a significant oil spill along the Gulf Coast. Chapter 6 addresses how to identify and handle contaminant-related wildlife. Various contaminants are addressed including mercury, lead, cadmium, solvents, ethylene glycol, and petroleum products. As new environmental catastrophes develop due to demands of our ever-changing world, *The Wildlife Techniques Manual* will be right there to provide

Figure 1. All editions of *The Wildlife Techniques Manual*, with the 7th edition featured as two volumes (far right).

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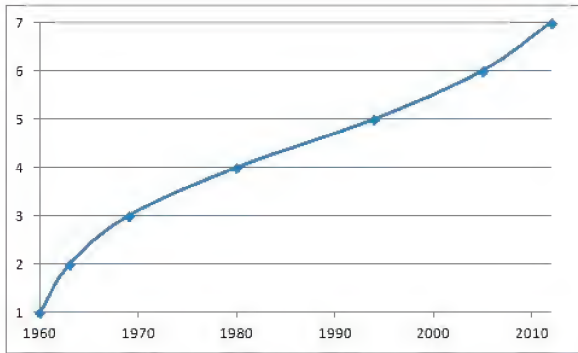
Figure 2. All editions of *The Wildlife Techniques Manual* plotted by year and edition; 1st and 2nd editions Mosby (1960, 1963); 3rd edition Giles (1969); 4th edition Schemnitz (1980); 5th edition Bookhout (1994); 6th edition Braun (2005); and 7th edition Silvy (2012).

guidance and techniques to preserve and conserve our natural resources.

The second volume of the 7th edition is key in understanding wildlife in the landscape and how it relates to the human dimension. With habitat loss, fragmentation, and modification, wildlife species are becoming displaced and have fewer places to go. The second volume discusses wildlife management on a variety of landscape types, including rangelands, inland and coastal wetlands, farmlands, and urban environments. As impacts to the remaining wildland areas continue, these chapters will become cornerstone guides on informing wildlife managers how to address a variety of wildlife management issues. Region-wide management plans will quickly become vital to the continued conservation of natural resources, and tools like Habitat Conservation Plans will (and should be already) be a paramount force in wildlife preservation (Randel et al. 2012).

In summary, this new and revised 7th edition could not have been published at a better time. The dynamic and changing landscape needs wildlife managers with a passion for wildlife conservation and preservation; this two volume techniques manual set is a vital tool in accomplishing the goals and aspirations of local and global wildlife biologists to the betterment of our planet. As this 7th edition is field-tested and exercised to its limits, I predict an 8th edition will soon need to be developed, as loss of habitat, disappearing biodiversity, and the ever-expanding human population will create new challenges that will need to be quickly addressed before it's too late.

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Appendix: List of chapters

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